AMPHIPACIFICA VOL. I SUPPL. 1, APRIL 20, 1995. 3

AN ACCOUNT OF *CADBOROSAURUS WILLSI*, NEW GENUS, NEW SPECIES, A LARGE AQUATIC REPTILE FROM THE PACIFIÇ COAST OF NORTH AMERICA.

E. L. Bousfield[1] and P. H. LeBlond[2]

ABSTRACT

Ethnological, testimonial, and photographic evidence pertaining to a large serpentine marine animal, sporadically observed in the coastal areas of the northeast Pacific Ocean and referred to in earlier literature as "Cadborosaurus" , is reviewed here. Through lack of a permanent reference specimen, the species was previously unrecognized by science. In our view, the records do contain published evidence of "specimens in hand", and are sufficiently voluminous and internally consistent to conclude that the animal is real, and merits formal taxonomic description. This account treats briefly, and to the extent of existing information, the external morphology, geographical distribution, behaviour, and aspects of the physiology, life style, and phyletic relationships of this large aquatic vertebrate animal. It is named and diagnosed here as *Cadborosaurus willsi*, new genus, new species, within vertebrate class Reptilia. In general features of head, two pairs of flippers, and short tail, the animal appear least unlike some plesiosaurs of Mesozoic age. However, its large distinctive hind flippers are apparently webbed to the true tail to form a broad fluke-like propulsive caudal appendage. When swimming rapidly at the surface, the trunk region characteristically forms into two or more vertical humps or loops in tandem behind the neck. The authors recommend that the species be considered for the COSEWIC primary list ofrare and endangered species of Canada.

INTRODUCTION

Little of the Earth's surface remains unexplored today, and one may presume that few large or conspicuous species of its fauna are left to be discovered and catalogued. Nevertheless, such animals continue to be found in the depths of the ocean and in forested mountain areas. Such discoveries are sometimes entirely unexpected, as exemplified by that of the coelacanth (Courtenay-Latimer, 1979) and of the megamouth shark (Taylor et al., 1983); others are heralded by glimpses and incomplete reports of unknown creatures before a specimen is finally secured. For example, the giant squid, *Architeuthis dux*, long a creature of uncertainty, was known only from occasional sightings, and from its remains in the stomach, and sucker marks on the skin, of sperm whales. The species was finally accepted by science after the strandings of numerous specimens in the 1870's (Aldrich, 1968). More recently, a new bovid reported from the Vu Quang area of Vietnam (*Pseudoryx nghetinhensis*) was described on the basis of a freshly collected pelt (Vu et al., 1993); the capture of a live specimen and death of a calf in captivity has recently been reported in the press.

Additionally, there are animals whose existence is still uncertain, and for which only testimonial, circumstantial, or insufficient material evidence is available. Heuvelmans (1982, 1984) has coined the term "cryptozoology" to describe the scientific study of such "hidden" creatures. Cryptids, as we shall call them, live at a frontier of scientific discovery, in a limbo between complete ignorance and scientific acceptance. The search for cryptids raises intense public interest as well as lively scientific controversy. In the absence of incontrovertible evidence, cryptozoology assesses the veracity of sightings, sifts through circumstantial evidence, and draws tentative inferences about the zoological characteristics of cryptids. Sometimes, as we will argue below, the accumulation of cryptozoological evidence may reach a level such that the question of existence is settled beyond reasonable doubt even before a specimen is actually secured, or captured again after initial release or loss.

This report concerns the status of a large marine cryptid, that has, over the years, been reported sporadically by the news media from coastal areas of the northeast Pacific Ocean. The creature is known under the popular name of Cadborosaurus . It is a large serpentine animal (adult body length 15 - 20 m.), clearly unlike any whale, pinniped, fish, or other existing vertebrate animal. It makes only brief appearances at the sea surface, presenting a distinctive head, a long neck, and the trunk region that often forms into a number of vertical humps or loops. Its swimming speed is astonishing to those who try to approach it, invariably unsuccessfully. Sightings of "sea-serpents" in this area have been mentioned in a number of works pertaining to cryptids in general (e.g. Mackal, 1980) and marine cryptids in particular (Bright, 1989; Heuvelmans, 1968). We refer to earlier reports (e.g. LeBlond and Sibert, 1973) and to local press reports. This study summarizes ethnological and testimonial information that is provided in much greater detail elsewhere (LeBlond & Bousfield, 1995), It utilizes authenticated photographs of a specimen, the Naden Harbour carcass, as a basis for description of the animal as a new genus and species. It concludes with a synopsis of the animal's biology, considerations on its behaviour and habitat, and a recommendation to assist in the preservation and continuity of this demersal marine vertebrate species.

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Although the biological classification of the animal itself continues to be a source of controversy, knowledgeable critics do not dismiss, as a figment of the imagination, the fact that a large, unusual animal type has been similarly referred to by many published or otherwise responsible observers over a geographically large region and a long period of time. Despite the published record concerning several "specimens in hand" (see LeBlond & Bousfield, 1995), none is today available for study in research institutions of the world. Two very small, ostensibly newly born specimens, have been reported captured and released during the past 25 years, but only one specimen of significant size has actually been examined, by museum personnel, during the past 60 years (Hagelund, 1987). The hunting of sperm whales is no longer a source of carcasses, and free-living adult specimens of 50-60 feet in length, weighing possibly 3 tons, and swimming at great speed usually at some depth, have never been captured by any means. Thus, a further large specimen is highly unlikely to become available during the foreseeable future. Although chance photographs of living specimens at the surface would not be unexpected, to date none is available. Our task, therefore, is to describe the fact of this animal more precisely, on the basis of previous and current evidence. Acceptance of a scientific name for this infrequently sighted species helps confirm it as a zoological reality, and one major obstacle to its qualification for placement on the world list of rare and endangered fauna is thereby removed, though others remain.

Acknowledgements

Our interest in solving the identity of modern sea serpents continues to be stimulated by further recent sightings of *Cadborosaurus* in coastal waters of British Columbia (to October, 1994). We thank all those who have communicated their commentary and observations over the years, by telephone, letter, or direct consultation, particularly Mrs. Phyllis Harsh, Mercer's I., WA., Mrs. Terry Osland, and Richard Smith, Sidney, B. C., Marjie Celona and Gary Kaulbeck, Victoria, B. C., and who have taken part in our organized "Caddy watches" during 1993 and 1994. We are especially indebted to Captain William Hagelund of Burnaby, B. C., whose recent book on the careers of whalers on the B. C. coast has provided major new information on the external morphology and biology of subadult and newly born specimens of *Cadborosaurus*. We are grateful for the support of Mr. James Wakelen, now of Victoria, whose presence at the Naden Harbour whaling station in 1937 has confirmed the authenticity of the archival photographs and undigested condition of the subadult specimen of *Cadborosaurus* removed from the stomach of a sperm whale at that time. The photographs now provide the principal basis for description of the external morphology of the species. We gratefully acknowledge assistance in accessing two major sources of information that have contributed to our sightings data base, viz., the scrap book of pertinent newspaper clippings prepared by the late Dr. G. Clifford Carl, former Director of the Royal British Columbia Museum and now stored in that institution, and a similar but more extensive scrap book prepared by the late Archie H. Wills, former editor of the *Victoria Daily Times*, now in the possession of his son, Kenneth Wills, of Victoria, to whom we are deeply indebted for its availability here. We thank Dr. John Sibert, University of British Columbia, for his early enthusiasm and participation in the search for evidence of the species, and Paul Stoddart who generously assisted with the extraction of information from newspaper archives. We very much value the generous co-operation of Dr. Craig. P. Staude, Friday Harbor Laboratories, WA., Dr. Derek V. Ellis, University of Victoria, B. C., Stan H. Orchard, Herpetologist and Research Associate, and other colleagues at the Royal British Columbia Museum, and Drs. Dale R. Calder and Desmond E. Collins, Royal Ontario Museum, Toronto, who variously provided study facilities, promoted seminars, lectures, and publicity on this subject, and lent sympathetic (but not always fully believing!) eyes and ears, to the evidence provided herewith.

The need to describe the basic features of morphology and probable life style of this enigmatic aquatic life form has led to a recent pooling of the authors' research resources. We are especially grateful to retired colleagues Dr. C. C. Lindsey, Vancouver, B. C., Dr. Ian McTaggart-Cowan, Victoria, B. C., and Dr. Francis R. Cook, North Augusta, Ontario, for their stimulus and encouragement in the formal description of this hitherto entirely cryptid form. We have also benefited from the commentary and publications of Dr. Chris McGowan, vertebrate palaeobiologist, ROM Toronto, who conducted earlier studies on the Loch Ness phenomenon and on swimming mechanisms in large vertebrate animals, and from Dr. D. A. Russell, former senior palaeobiologist, CMN (Ottawa), who has contributed greatly to knowledge of the morphology and paleoecology of large reptilian animals of the Mesozoic Era.

This paper is based partly on an oral presentation by the authors at the Annual Meeting of the American Society of Zoologists, Hyatt-Regency Hotel, Vancouver, B. C., December 29, 1992 (Bousfield & LeBlond, 1992).

BACKGROUND PREAMBLE

Ethnological evidence. The failure of science to officially recognize an organism does not mean that nothing is known about it. Comoro Islanders already knew about the coelacanth well before its formal scientific discovery in 1938. An animal may be "ethno-known" (Greenwell, 1985), outside the formal framework of science, before a type specimen is captured for official confirmation. Ethnological information, in the form of carvings and art work (artifacts, petroglyphs) and stories or local mythology, can contribute to the profile of a cryptid. Some report or depiction of Caddy in native art and legends would therefore not be unexpected.

Prehistoric petroglyphs are a common feature of exposed rocky shorelines in the coastal waters of the northeast

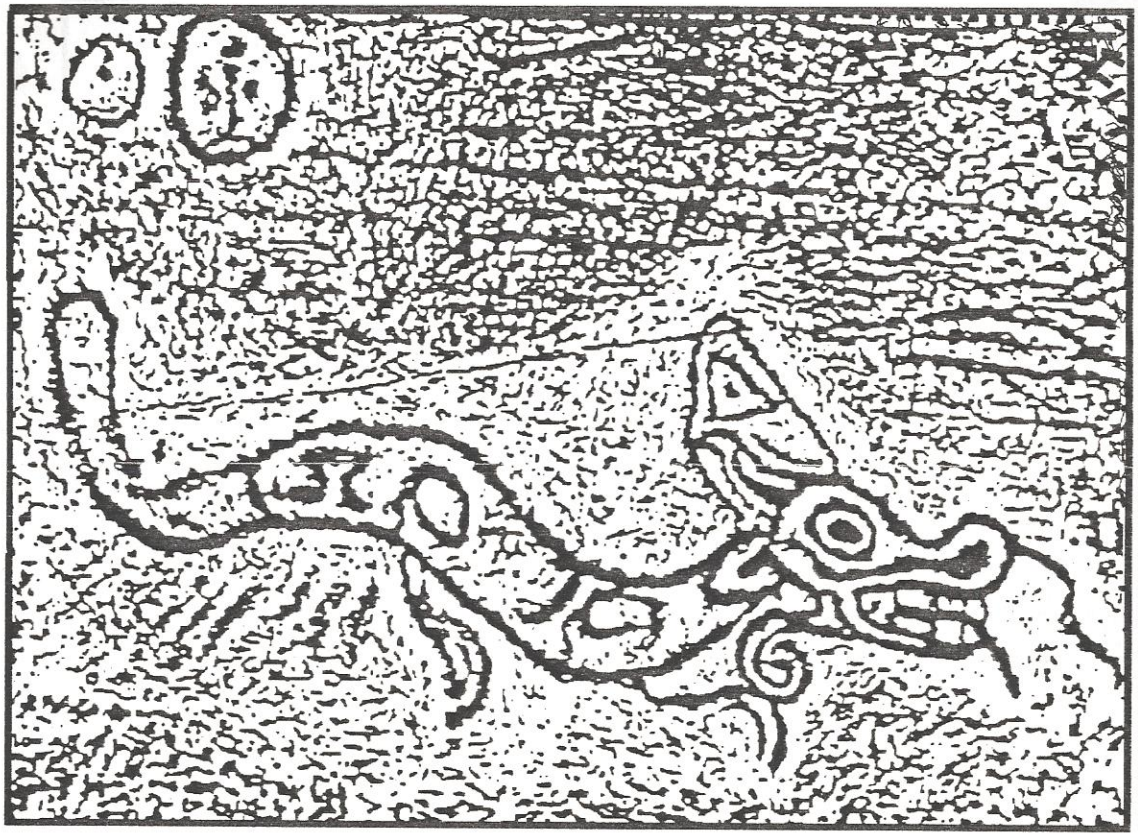

FIG. 1. Petroglyph from the Monsell site, Nanaimo River (after Hill and Hill, 1974)

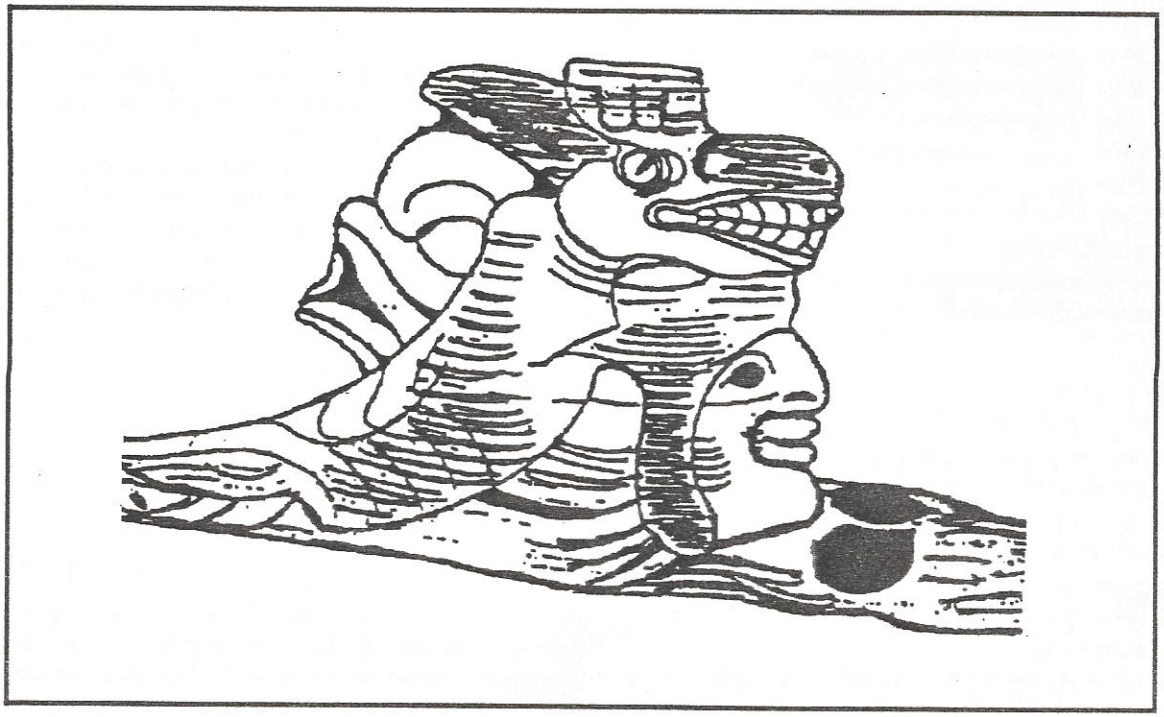

FIG. 2. Atlatl, Scagit River site, Washington (~200 A.D.) (after Taylor & Caldwell, 1954)

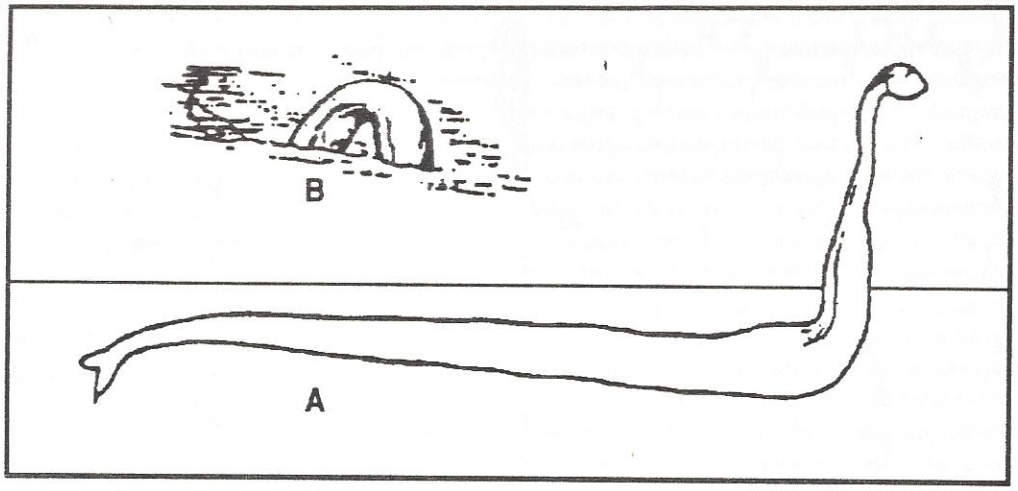

FIG. 3. Marine cryptid off Queen Charlotte Islands, 1897. A. Habit sketch by Fergusson & Walker. B. Single hump of body, swimming at surface (after Mattison, 1964).

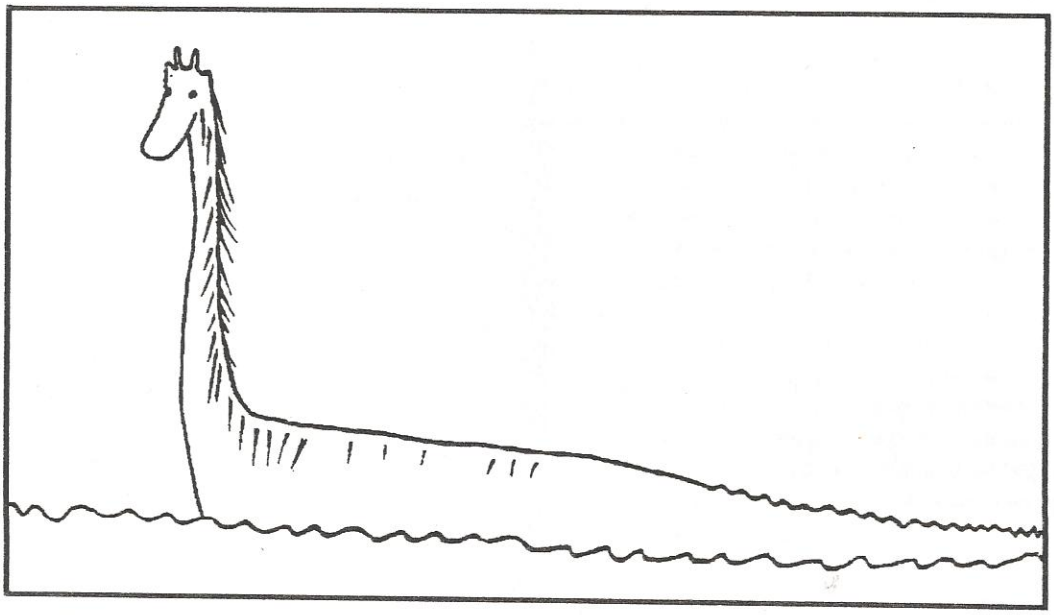

FIG. 4. Marine Cryptid, off Yachats, Oregon, January, 1937. (W. Hunt sketch, after LeBlond & Sibert, 1973)

Pacific shores (Hill and Hill, 1974). They consist of shallow incised drawings representing a variety of figures: fish, human faces, and geometrical designs. Among these is an occasional representation of a zoologically unknown animal with features reminiscent of the descriptions of Cadborosaurus. An example (Fig. 1), from the Monsell site, near the Nanaimo River on Vancouver Island, shows an elongated body, a relatively large head with prominent eyes, "horns" and mouth, and both fore and hind limbs. Other petroglyphs, such as that from Gabriola Island, show a similar creature without hind limbs and broadened tail, also bearing an overall similarity to the Caddy profile we know today.

A well authenticated pre-contact artifact is the yew-wood spear thrower (atlatl) found while dredging in the Skagit River, Washington State, in 1952 (Taylor and Caldwell, 1954) and now in the collection of the Museum of Anthropology of the University of British Columbia. Using carbon-14 methods, Fladmark et al (1987) showed that the atlatl had been carved circa AD 200. The handle of the atlatl, shown in side-view in Fig. 2, is sculpted in the form of an animal similar to that depicted in the petroglyphs, with elongated body, prominent teeth, eyes, and head appendages. The fore legs clasp the temples of a carved human head; the hind legs are pressed against the animal's tail.

Indian legends about sea-serpents abound. For example, the Manhousat people of western Vancouver Island spoke of the rarely seen, semi-legendary *hiyitl'iik*, "he who moves by wriggling from side to side", an animal seven or eight feet long which moved quickly on land as well as on water (Ellis and Swan, 1981). *Hiyitl'iik*'s head and back were covered

with long hair, represented with strips of cedar bark dyed red on the ceremonial sea-serpent mask. Zoological interpretations are, however, confused by the further mention that this creature could grow wings and take flight at will! This image does not fit the profile of Cadborosaurus above.

Are the artifacts and the stories of sea-serpents in northeast Pacific waters (e.g. Pascua, 1991) to be interpreted as unsystematic descriptions of real animals, as an optimistic cryptozoologist might surmise? Or are they, like the Pacific Northwest thunderbird, purely mythical creatures? Might reality perhaps fall somewhere in between, as in the case of the mystical medieval unicorn mascarading for the Indian rhinoceros (Ley, 1966)? Be it real or mythical, there is certainly a solid tradition of a large sea-serpent in local folklore which clearly antedates the arrival of the European settlers.

Testimonial Evidence.

To select the most credible and informative testimonial evidence available from newspaper accounts, eye-witnesses, and previous compilations, we have followed two simple rules. First, **the unidentified object must be unambiguously alive**. If not, we have rejected the sighting, as perhaps not even pertaining to an animal. We thus rejected all puzzling and ambiguous appearances of potential drifting branches, bobbing logs, objects that do not move over periods of time, or wave-like objects. Second, **could the creature sighted possibly have been some known animal**? If there is the slightest suspicion that this might have been so, either in the opinion of the witnesses or through interpretation of their report, the testimony was rejected as potentially not relating to this cryptid. This second criterion eliminated all observations of animals seen at a great distance or under poor viewing conditions. We have only retained sightings documented in print and reports from eye witnesses; we have not included second-hand reports ("I know someone who saw..."). Many of these eye witnesses are still living, and of the many subsequently re-interviewed, none had lost faith in their original observation and belief in it.

From the files of the main British Columbia newspapers (*Vancouver Sun*, *Vancouver Province, Victoria Daily Colonist* and *Victoria Daily Times),* previous compilations (Heuvelmans, 1968; LeBlond and Sibert, 1973; documents of G. C.Carl and A. H. B. Wills), the assistance of other zoologists, and written as well as oral contributions from eye witnesses, we have identified 187 sightings that satisfy our selection criteria (details in LeBlond & Bousfield, 1995). More than one-third of these sightings involved two or more observers. The sightings range in time from 1881 to the present, and in space from the Alaska "Panhandle" south to the Oregon Coast. Records tend to be concentrated off the mouths of large west coast estuarine systems (Skeena, Fraser, Columbia), especially in the waters of what is sometimes called the Salish Sea: the interconnected channels of the Strait of Georgia, Puget Sound and Juan de Fuca Strait. A detailed list of sightings, too voluminous to be included here, but available from the authors on request, will be found in LeBlond and Bousfield (1995), where the evidence for *Cadborosaurus* is presented in a more complete and popularly accessible format (see also LeBlond, 1993). Sketches by selected first-hand observers, reproduced here (Figs.3-5), illustrate outlines of *Cadboro-saurus* most frequently observed at the sea surface for which photographs or more detailed renditions are unavailable.

The typical sighting involves an element of surprise: witnesses do not expect to see something unfamiliar, and usually first interpret what they see in terms of known objects or animals. On the other hand, planned expeditions (of the authors and colleagues) to view the species in the Strait of Georgia and Gulf Islands region met with no sighting successes in 1993 and 1994. Shore-based observers quite often have their attention first drawn by sound — a hissing, snorting or blowing noise which causes them to look up from what they were doing and pin-point the source of the sound. After they have overcome their perceptual confusion, they often continue to describe the strange animal(s) in terms of analogies with, or resemblances to, known creatures. However, despite the widely differing degrees of biological knowledge and reporting acuity among the observers, their individual accounts of this animal are surprisingly in general agreement, and are consistent over time. Caddy's most striking features are (1) its dimensions: large, ranging from 5-15 metres; (2) its body form: snake-like or serpentine, lacking dorsal fin (Figs. 3, 4, 6, 8); (3) the appearance of its the head: relatively small, and variously described as resembling in lateral view that of a sheep, horse, giraffe, or camel (Figs. 4, 5, 6, 8, 11); (4) the eyes, generally described as large, reflective, and essentially forward-facing, rather than lateral (Figs. 4, 5, 11); (5) the length of its neck: elongate, ranging from 1 - 4 metres (Figs. 4, 5); (6) the vertical humps or loops of the body, arranged in tandem series directly behind the neck (Figs. 3, 5, 15B); (7) the foreflippers: narrow, thin, lacking digits (Fig. 7, 11A); (8) the tail region, formed of the posterior pair of flippers webbed to the tail proper, and together forming horizontal "pseudoflukes" (Figs. 3, 7, 12, 13); (9) the swimming speed: extremely high, clocked at up to 40 m. p. h. at the surface; and (10) its ability to remain submerged, apparently indefinitely, while metabolically active.

No other known creature, living or paleohistorical, agrees with the description of Cadborosaurus in more than a few, and never in all ten, of these major categories. However, sometimes only a log-like outline at the surface, or only a head and long neck are seen; at other times, a long serpentine body, with "coils" arching over the water, is reported, rendering identification less positive. It is the only large presumtive vertebrate animal that, to our knowledge, does not necessarily break surface with its head and/or immediately breathe air. Quite often, only the back of the animal is seen, with the head and neck not emerging before the body sinks out of sight. Each sighting must be assessed on its individual merits, in relation to the number and/or quality of points of agreement with the major descriptive criteria above.

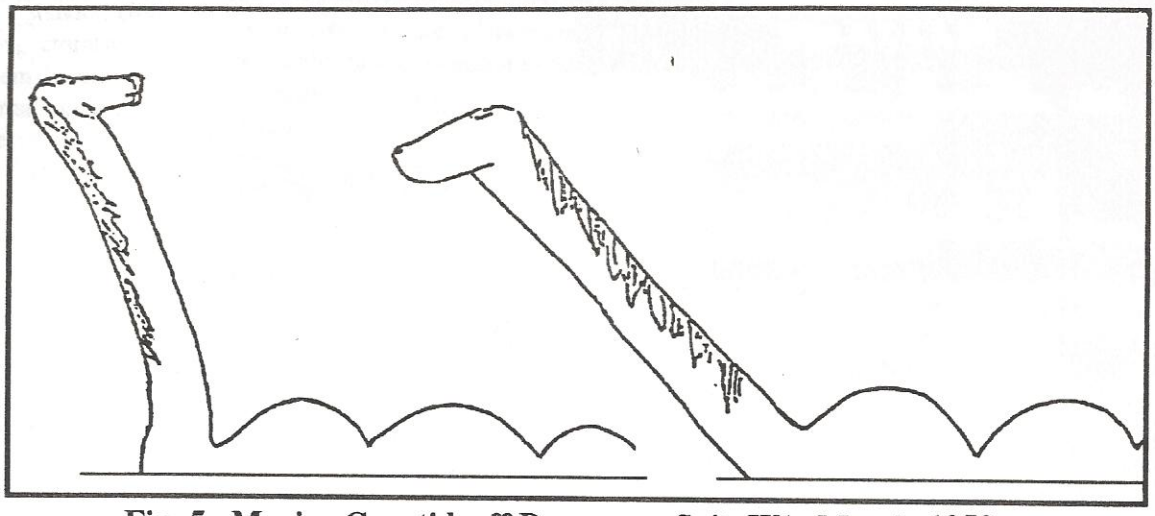

Fig. 5. Marine Cryptid, off Dungeness Spit, WA, March, 1953. (M. Stout sketch, from LeBlond & Sibert, 1973).

Attempts by "armchair" or "sight-unseen" critics to ascribe these sightings to various other possibilities usually suffer from even greater limitation of credibility. Suggested alternatives often involve large marine vertebrate animals that are well known to science and to the critics, including various fishes and marine mammals and/or parts thereof, or floating inanimate objects. However, all fishes (including the large oarfish and other ribbon fishes) can be ruled out instantly, not only because they are not air-breathers, but because none has a neck (let alone one that measures up to 20% of total body length!), not even in the highly modified but tiny "seahorse", where the pectoral fins are also located immediately behind the head. Most fishes (certainly large ones) also have distinct pelvic fins and/or one or more dorsal fins, and a **vertical** tail fin, not consistent with basic features of Cadborosaurus. The large basking shark (*Cetorhinus maximus*), often seen floating lazily at the surface with head submerged in B. C. coastal waters (Darling and Keogh, 1994), has a very thick body, vertical tail and dorsal fins, and also no neck; its jawless skeleton, occasionally washed up on the beach (above), has a straight column of similar fish-like vertebrae (lacking dorsal and lateral bony processes) and is in no way serpentine or coiled as in a carcass of Cadborosaurus (Figs. 6, 8). With respect to large marine mammals, the whales (cetaceans) have bifid, fluke-like (horizontal) tails but only a single anterior pair of flippers, and all have a thick non-serpentine body, a large head with lateral eyes, usually a dorsal fin, and lack a distinctive neck. Some pinnipeds have relatively slender bodies, a distinctive neck, and forward-facing eyes, but the body is short (<6 m), has two pairs of flippers, all functioning independently, and a small tail. When swimming at the surface, no mammal shows more than one body hump behind the head, whereas Cadborosaurus typically shows 2-3 humps, occasionally 5 or more. On rare occasions, when swimming in a line, several seals or sea lions might simulate a "multiple hump" effect. However, such simulations are fleeting, and do not maintain a constant height or distance between themselves as do the vertical humps or coils of Cadborosaurus. Moreover the head continuously reappears in such simulations. All whales and pinnipeds breach the surface head first, and usually breathe immediately, whereas Cadborosaurus is often seen at the surface with the head showing either not immediately, or not at any time. With respect to inanimate objects, large floating kelp masses and logs are nearly stationary (speed no greater than water currents) and remain indefinitely at the surface. The animal usually travels quickly, but seldom remains at the surface for more than a brief duration, never indefinitely. Thus, a true sighting of Cadborosaurus is an experience that is unique from both morphological and behavioural standpoints, and is unlikely to be mistaken for anything else.

SYSTEMATICS

Class Reptilia
Subclass Euryapsida? Order Plesiosauria?

Cadborosaurus, new genus

(?) *Halshippus* Heuvelmans, 1968: 566 (*nomen nudum*)?.

Type species: *Cadborosaurus willsi*, new species, original designation.

Diagnosis: Large, aquatic, elongate and slender-bodied reptilian with distinctive, head, neck, trunk, and tail regions; proportions allometrical.

Head relatively small, short, broad; upper and lower jaws produced anteriorly. Mouth large, teeth numerous, large, sharply pointed, lining upper and lower jaws. External nares apical. Eyes large, orbital sockets directed mainly forwards.

Neck medium to long, slender, vertebral number presently indeterminable (~10?); hair-like filaments forming a "mane" along the nape (at larger sizes) .

Trunk slender, elongate, snake-like or serpentine, broadest in the pectoral region, forming into vertical humps or coils in tandem directly behind the neck during forward propulsion; external surface essentially smooth, without conspicuous scales; dorsal ridge low, not conspicuously crested, lacking fin(s); vertebral number ~ 26.

Front (pectoral) limbs paired, short, fin- or flipper-like, apparently functioning mainly in steering and elevation rather than propulsion.

Hind (pelvic) limbs paired, medium, "foot" expanding distally, digits elongate, webbed together.

Tail relatively short, tapering to apex, crested dorsally and dorso-laterally; vertebral number ~9-10; tail apparently fused or webbed together with hind limbs to form a horizontal, bifid, fluke-like, propulsive caudal appendage.

Etymology: The vernacular name "Cadborosaurus", a combining derivative of Cadboro Bay, Victoria, where sightings were originally most frequent, and the Greek root "sauros" meaning lizard or reptile, is here given formal new generic taxonomic status as *Cadborosaurus*.

Taxonomic Commentary: The genus is essentially reptilian in body form and probable poikilothermal physiology. It is characterized by a small head, long neck, elongate, serpentine trunk, and apparently lacks a thick external layer of fur or subcutaneous layer of blubber typical of homeothermal mammals that live year-round in cold waters (4-12°C.). The newly born precocial young are of relatively small size, also an essentially reptilian feature (p. 21).

The animal grossly resembles some Mesozoic plesiosaurs in the small broad head with forward facing eyes, large mouth with numerous teeth in upper and lower jaws, two pairs of flipper-like limbs, and relatively short caudal region. However, unlike plesiosaurian genera, *Cadborosaurus* possesses unique features of the trunk and tail regions (above).

The formal taxonomic name *Halshippus* Heuvelmans, 1968, is based on a description of the North Atlantic cryptid species *Halshippus olai-magnai* Heuvelmans, 1968, commonly known as the "merhorse" (p. 23). In it he includes nearly 30 records of *Cadborosaurus* from the north-eastern Pacific region. Bernard Heuvelman's species description (pp. 552-557) is remarkably detailed and perceptive, and contains generic and/or species character states somewhat similar to the above in mentioning the forward-pointing eyes, the "long floating mane" of possible respiratory function, the vertical loops of the trunk region, and the " . . false tail formed by two webbed hind feet joined together . . . ". It is also accompanied by a habit sketch of the species at the surface (Fig. 19). Unfortunately the species description is not based on an actual specimen, or reliable photograph of an actual specimen, and a holotype has not been named nor deposited in a permanent study location. The description thus technically does not conform with the pertinent ICZN code. Regrettably, therefore, Heuvelman's taxonomic name is here considered a *nomen nudum*..

Cadborosaurus willsi, new species
(Figs. 6, 7, 8, 9, 10)

(?)*Halshippus olai-magni* Heuvelmans, 1968: 552-557, 566, fig. 142 (*nomen nudum*)?

Vernacular Attributes.
Cadborosaurus (sp.) Wills, *Victoria Daily Times*, Oct. 11, 1933.
"Baby Sea serpent". Report Naden Harbour Whaling Station to Department of Fisheries in Anon. Fisheries New Bulletin, VIII (95) 1937: 2).
"(Fetal) baleen whale" attr. F. Kermode, *Victoria Daily Times*, July 23, 1937.
Infant "Caddy" Hagelund, 1987: 178, 2 figs.

Material Examined: Three photographs of a juvenile specimen (~3.8 m total body length), removed from the stomach of a sperm whale flensed at Naden Harbour whaling station, Queen Charlotte Islands, British Columbia, in early July, 1937. The juvenile specimen, and the photography, were witnessed by the whaling station blacksmith, Mr. James Wakelen (Fig. 14), now residing in Victoria, B. C. Parts of this specimen (portion of a backbone, piece of "baleen" and portion of skin) were reportedly forwarded to the Pacific Biological Station at Nanaimo and/or to the Royal British Columbia Museum, Victoria, soon afterwards. The pieces were identified by museum director Francis Kermode (in Victoria) as parts of a "fetal baleen whale" (p. 10). This original and potential holotype material was apparently not deposited (nor an accession record of it made) in the collections of RBC Museum (fide curator David Nagorsen) and is considered lost to science.
Holotype. G. V. Boorman photographic album*, print No. 37, fronto-lateral view of Naden Harbour juvenile specimen, in archival files of the Vancouver Maritime Museum, Vancouver, B. C. (An apparent duplicate of this photograph is on file in the Provincial Archives, Victoria, British Columbia).
Paratypes. (1) G. V. Boorman photographic album print No. 38, lateral view of Naden Harbour juvenile specimen, in archival files at the Vancouver Maritime Museum , Vancouver, B. C. (An apparent duplicate of this photograph in on file in the Provincial Archives, Victoria, British Columbia).

(2) F. S. Huband photographic print, similar to but slightly different from the Holotype; B. C. Provincial Archives, Victoria, Cat. No. HP 52840; Neg. No. H-4767.

Selected credible sight records: see detailed list of 187 sightings, mostly published since 1881, in LeBlond & Bousfield (1995); also available on request.

Diagnosis of Naden Harbour Juvenile Specimen. With the characters of the genus. The following character states may also be of species level significance:

Head (estimated length ~ 0.3 m), horse-shaped or camel-

* album entitled "Whaling in the Queen Charlotte Islands , 1937" by G. V. Boorman, Victoria, B. C.

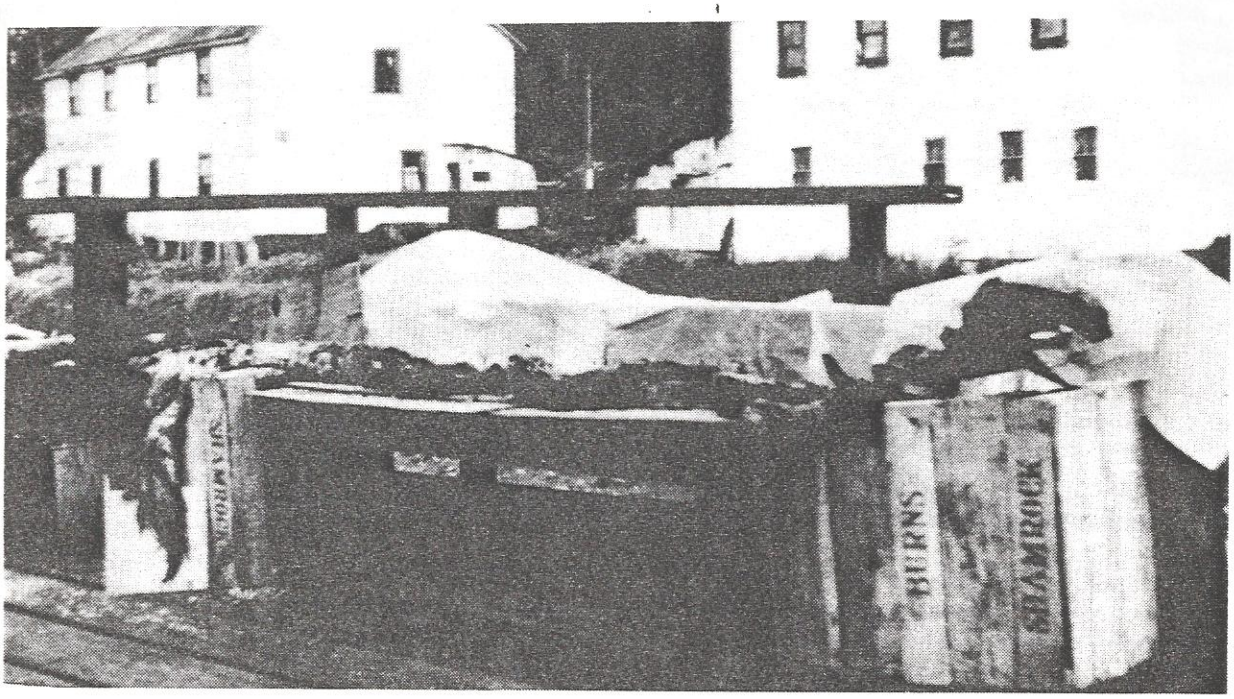

FIG. 6. Juvenile *Cadborosaurus*, Naden Harbour, B. C., July , 1937 Antero-lateral View. G. V. Boorman photo (Holotype)

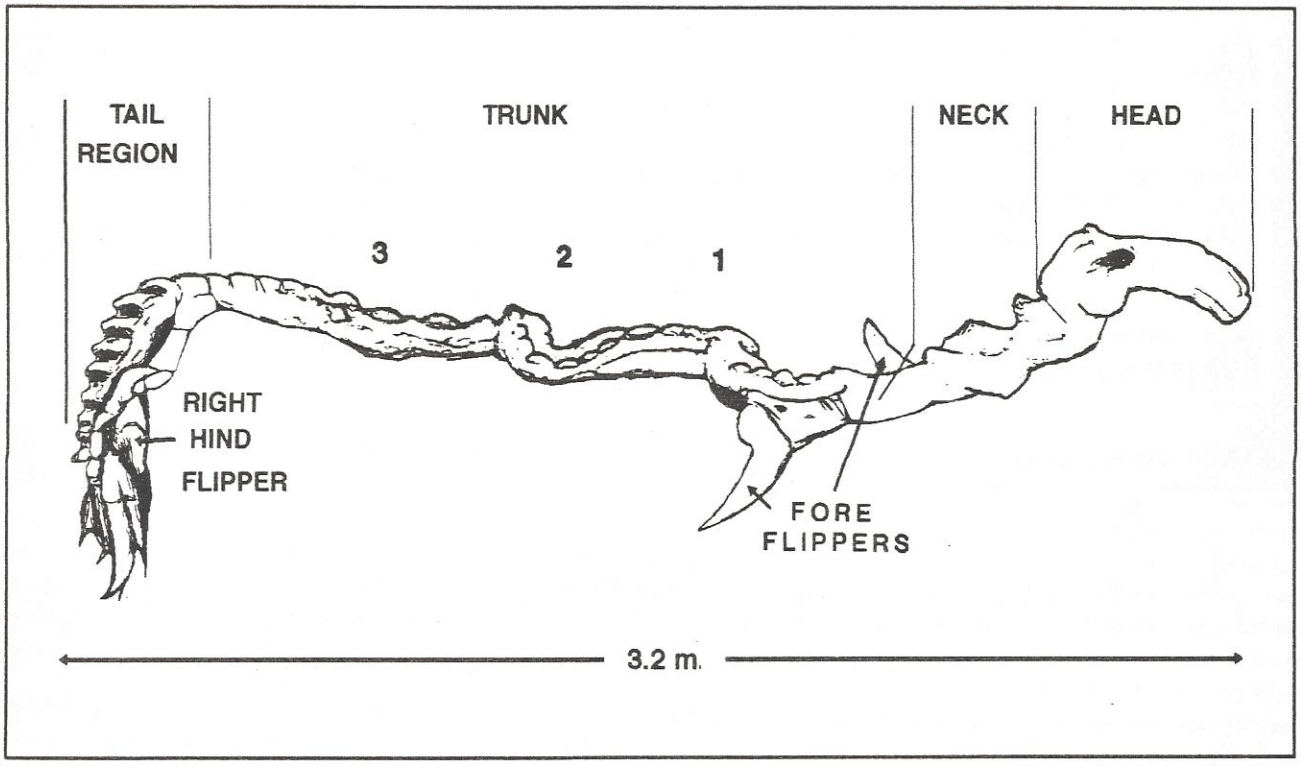

FIG. 7. Trace Outline of Juvenile Cadborosaurus, Naden Harbour, B. C. (from G. V. Boorman photograph (Holotype), antero-lateral view)

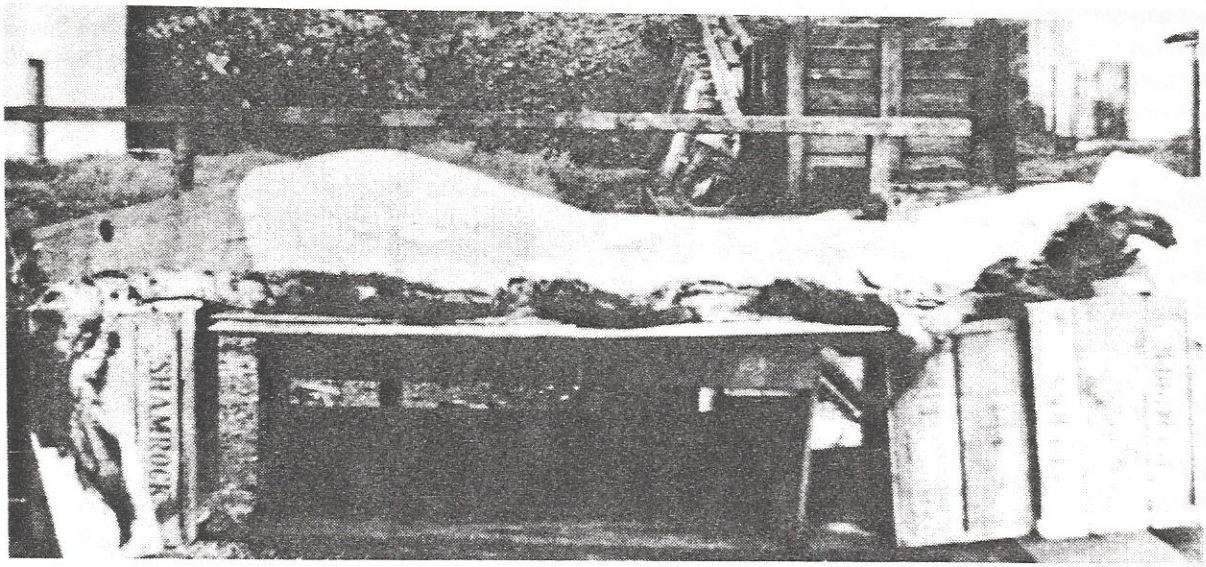

FIG. 8 Juvenile *Cadborosaurus*, Naden Harbour, B. C., July, 1937. (G. V. Boorman photograph (Paratype), lateral view)

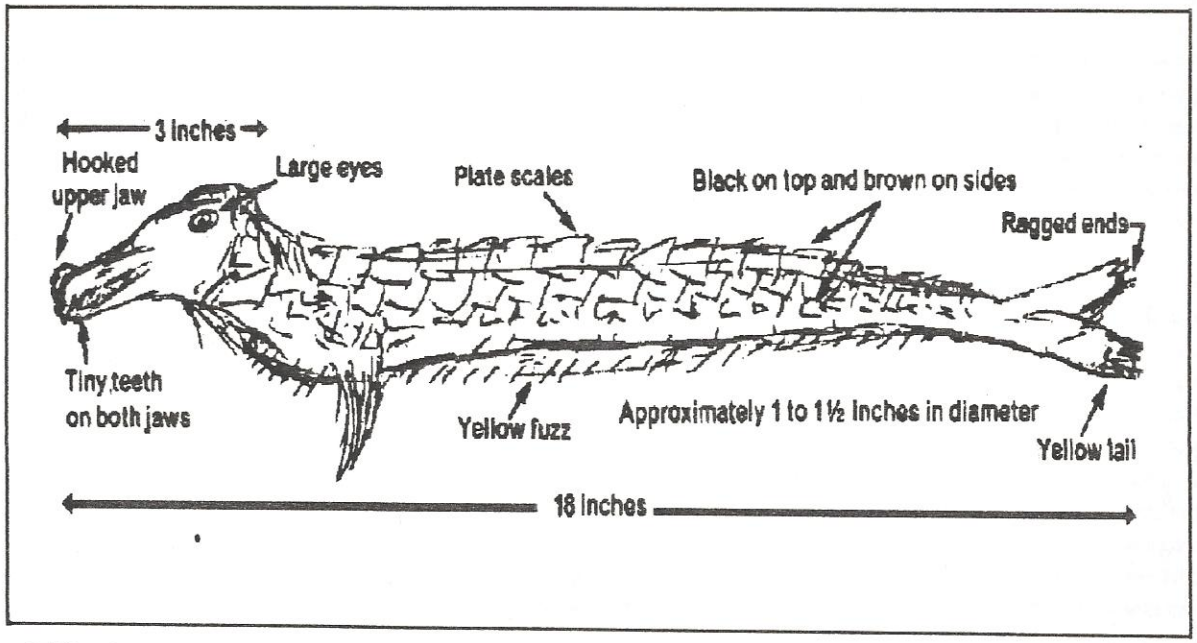

FIG. 9. "Baby" *Cadborosaurus*, Pirate's Cove, B. C., August, 1968. Lateral View. (W. A. Hagelund sketch; from Hagelund, 1987)

like in profile. Crown with two small humps posterior to presumptive eye sockets. Ridge of presumed nares bulging forwards and downwards towards tip of snout.

Neck (crumpled in photographs) length ~0.6 m; diameter not determinable. Mane, or hair-like filaments not present.

Trunk, estimated pectoral-pelvic length ~ 1.7 m; mean diameter ~ 0.15 m; dorsum with low rounded tubercles each 5-6 cm. in length at base; tubercles (about 26 in number) may correspond to vertebrae of the spinal column.

Anterior (pectoral) flippers medium, thin, narrow, length of each ~ 0.4-0.5 m, broadest medially at "elbow", narrowing to acute tips; nails or claws not visible. Posterior right flipper large, apparently webbed to tail proper, distally broadened, with unequal "pedal digits" webbed together (left flipper presumably hidden from view behind white card) (Figs. 6, 8, 12). The entire tail region (estimated length ~1.3 m) is broader , deeper, and lighter in colour (yellowish in new-born) than the trunk. Lateral and trailing edges of tail with sharp spine-like processes. Apical segment of tail proper is short, rounded.

Diagnosis of presumed adult animals (based on testimonial evidence published in the press and contained in the personal compilations of G. C. Carl, A. H. B. Wills, and

interviews with recent witnesses (see Acknowledgments; also LeBlond & Bousfield, 1995).

Body form generally similar to that of the juvenile described above, except as detailed below. Sexual dimorphism suspected but not ascertainable from data base. Body length (estimated) ~15-20 m.

Head short (~ 0.8 m), basally broad (~ 0.5 m), capable of swiveling in air through 180 ^{o} angle (Fig. 5). Eyes large, luminous, often reddish in colour. Short, paired, knob-like protruberances, superficially similar to those of a giraffe, may be present above and posterad of eye sockets. Neck elongate, length up to 4.0 m, often held stiffly forward at an angle to water surface. Nape of neck, from head to trunk, may bear mat or mane of hair-like filaments, having a texture described as "like coconut fiber" and reddish in colour.

Trunk, anterior portion relatively thick, up to one metre or more in diameter, possibly increasing allometrically with size and age. When swimming rapidly at the water surface, the trunk region often forms into 2-5 or more vertical humps or loops, each separated by about its own width (diameter), and projecting above the water surface. The presumed function of the vertical hump formation is described below (p. 17). Tail region, length ~1/4 body total, dorsally and dorso-laterally crested or crenulated, somewhat crocodilian in form.

Diagnosis of presumed new-born juvenile (based on published sketch and text diagnosis of Hagelund (1987: 178, fig. 1) that is assumed to be correctly associated as the young of *Cadborosaurus willsi*.

Body length ~40 cm (16 inches). Head relatively large, with large, somewhat forward-facing reflective eyes; snout "whiskered" and dorsally hooked; mouth with lips that "curl back" to expose teeth in both jaws. Neck allometrically relatively short, thick; nape with scales. Trunk relatively short and thick; dorsum protected by large plate scales; venter covered with "soft yellow fuzz" (Hagelund, loc. cit). One pair of small subtriangular flippers attached in the pectoral area. Tail spade-shaped, consisting of two overlapping flipper-like fins, presumably representing true limbs (Hagelund, pers. communication), but not elucidated in his published sketch or text (Fig. 9).

Etymology. The species is named in honour of the late Archie H. B. Wills, former editor of the *Victoria Daily Times*, who was instrumental in selecting the generic name *Cadborosaurus* ("lizard of Cadboro Bay") for this remarkable aquatic vertebrate form.

Distribution and ecology. The species ranges in the North Pacific Ocean from southeastern Alaska (off Kenai peninsula) to the Monterey Bay region, Central California (Reinstedt, 1975), in coastal shelf waters, pelagically and epibenthically over the continental slope, probably to considerable depths (300-1000+ metres)*, in temperatures of about 4-12 ^{o}C, or slightly higher in summer (Thomson, 1981), and in areas of upwelling such as Johnstone and Juan de Fuca Straits. The species tends to occur more frequently in inland seas (e.g. Strait of Georgia) during spring (March-May) and fall (October-November) and offshore during the winter months. Records of presumed immature specimens from coastal lakes, e.g. Harrison L. (Randall, 1981), are problematical.

Material Commentary. Although the paratype photographs had been published previously in non-taxonomic literature they were named and described in vernacular terms only, rather than formal taxonomic terminology, and are thus available for designation as primary types in this study. Thus, paratype photograph No. 1 was published in Hagelund (1987, p. 179), and paratype photograph No. 2, by F. S. Huband, appears to have been published in the *Victoria Daily Colonist*, October 31, 1937, and republished in the *Vancouver Sun*, May 5, 1960. The latter photo print had been significantly retouched, and the surface "smoked" to reduce highlights, and is therefore little utilized here.

The authenticity of the photographs and the original specimen is supported by previous accounts (e.g. Hagelund, 1987), and by eye-witness James Wakelen, now of Victoria, B. C. The body of the original specimen had been laid out by the flensers on a 5 ft. (1.7 m) table top, its surface lengthened by upended packing boxes. In order to enhance the photographic record, the top and elevated back-ground frame had been draped with white sheets, suitably positioned behind the head, neck, and trunk, and a white card placed behind the tail. The card is held out at an angle from the background box presumably by the bulk of the left flipper that is hidden from view. The background in the two photographs (Figs. 6, 8) includes, variously and from different angles, the bunkhouses of the flensers, some work buildings, and a guard rail beside the shore path. A station layout plan is provided by Hagelund (1987). Following closure of the station in 1942, all buildings were dismantled and little trace of them remains today. Prints from the original photographic negatives (not located), developed separately by the station manager, the late F. S. Huband, and by the first-aid officer, G. V. Boorman, are of fair to good quality. Measurements of body length can be made from the full lateral view prints (Figs. 6-8) but because of specimen curvature in the two-dimensional photographs, measurements are close approximations only (Fig. 7).

The original specimen was entire, undigested, and in generally good condition. The neck region, however, appears to have been severely crushed, perhaps by the killing action of the whale's jaws on its prey prior to being swallowed whole. The whale itself had been harpooned and killed by one of the station "colour" boats, on the fishing grounds off Langara I., in mid-July, 1937. It was then towed, via Parry Passage, to the Naden Harbour station and flensed soon afterwards. During this short pre-flensing period,

*Estimated from known feeding depth of the sperm whale (500-3000+ m) (see Hoyt, 1984), and depth distributions of other prey items: e.g. ragfish (to 732 m); six-gilled shark (to great depths) (see Hart, 1973); giant squid (deep sea) (see Aldrich, 1968).

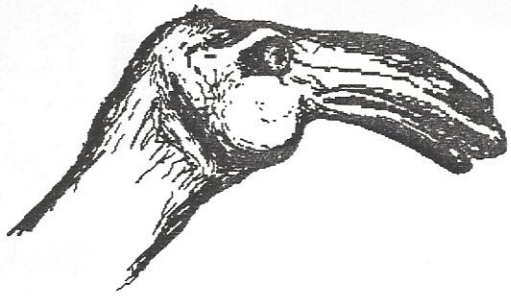

FIG. 10. Head of *Cadborosaurus*, lateral view Enlargement from G. V. Boorman photos, (Holotype and Paratype)

estimated at 10-12 hours, slight digestion and shrinkage of surface features of the specimen in the whale's anterior stomach may have taken place. However, the serpent's body was essentially intact and easily identifiable as unlike any marine animal previously known to the station whaling men (Wakelen, personal communication). It was also totally unlike other large deep-water prey animals such as 6-gilled sharks (*Hexanchus griseus*), ragfish (*Icosteus aenigmaticus*) and giant squid (*Architeuthis* sp.) regularly encountered by the flensers when searching sperm whale stomachs for ambergris (*fide* J. Wakelen; see also Cowan, 1938; Hagelund, 1987, p. 177).

In sequel, parts of this specimen had apparently been sent shortly thereafter, probably salted or iced but without benefit of modern preservation techniques, possibly to the biological station at Nanaimo (*fide* G. V. Boorman document) and eventually to the British Columbia Museum in Victoria. The whaling boat trip from Naden Harbour to Victoria docks was normally about two days' duration, and 3 days if towing another vessel (Hagelund, 1987). Identification of the parts was made by the museum director, Francis Kermode, who had some experience as a taxidermist but apparently lacked formal training in biology (Corley-Smith, 1989). Kermode opined, to the Fisheries Department and to the press (*Victoria Times Colonist,* July 23, 1937) that "there was little doubt that the portion of a back-bone, the piece of baleen, and the portion of skin forwarded to the museum were pieces of a baleen whale . . of premature birth". Such an identification was implausible in the extreme, and uncomplimentary to the professional whalers, flensers, and other personnel at the whaling station (including James Wakelen who stood beside the carcass as it was being photographed). Nor did it explain how such an item could find its way into the stomach of a sperm whale in the first place! Wakelen and station colleagues saw many fetal baleen whales during their years at the station and were quite familiar with their external morphology (Fig. 14). In his basically resembles the mother animal (Fig. 14). Regrettably, the museum's curator of vertebrate animals, Dr. Ian

Note:
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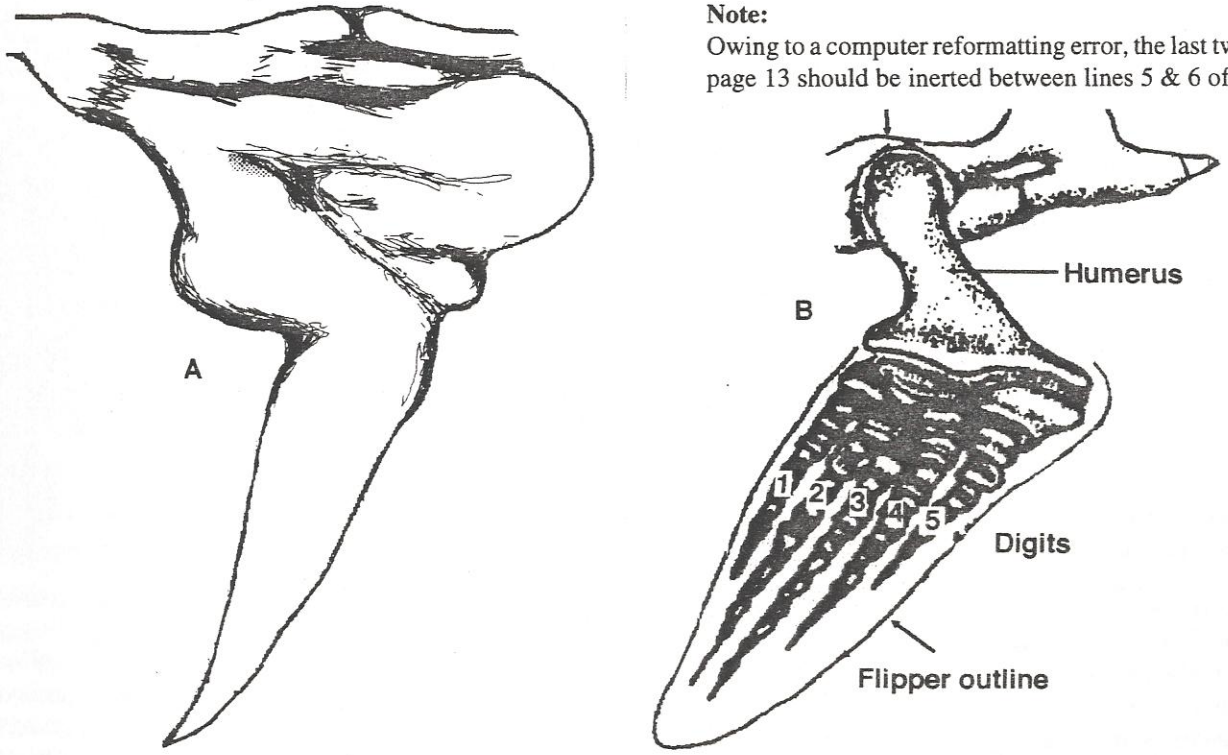

FIG. 11. Reconstruction of Right Front Limb (Foreflipper)
A. *Cadborosaurus* (from G. V. Boorman photo (Paratype)
B. Plesiosaur (*Cryptoclidus*) Skeletal structure (after Norman, 1985).

FIG. 12. TAIL REGION OF *CADBOROSAURUS*: ENLARGED FROM G. V. BOORMAN PARATYPE PHOTO

report to the Fisheries Department (1937), Kermode described a "tail resembling a single blade of gill bone found in whales' jaws", apparently mistaking the ribbed and marginally spined tail as actual whale bone (baleen). A fetal baleen whale, whatever its size, is thick-bodied, not serpentine and McTaggart-Cowan, was in the field near Revelstoke at that time. On his return to Victoria in late July, he was not made aware of this material, nor did he view it at any time. He did view one of the archival photographs many years ago, and the F. S. Huband photograph that was shown to him recently by the present authors. Nothing of the material nor of formal accession records can now be traced at that museum (*fide* D. Nagorsen, A. E. Peden, RBC Museum), nor at Nanaimo (*fide* T. MacDonald).

The three photographs apparently received no serious consideration at those times, nor subsequent attention or recognition by the scientific community. Although the Huband photograph had been retouched, concealing important detail, both original photographic prints of G. V. Boorman had been preserved safely and were available for the present study. The Huband photograph was brought to our attention through the diligence of RBC museum ethnologist, Grant Keddie, in January, 1992. The Boorman photographs were discovered only recently (January, 1995) at the Vancouver Maritime Museum, and a duplicate set at the Provincial Archives in Victoria. An enlargment of the tail section was made, with kind permission of the Maritime Museum, reproduced here (Fig. 12) from which a computerized outline was

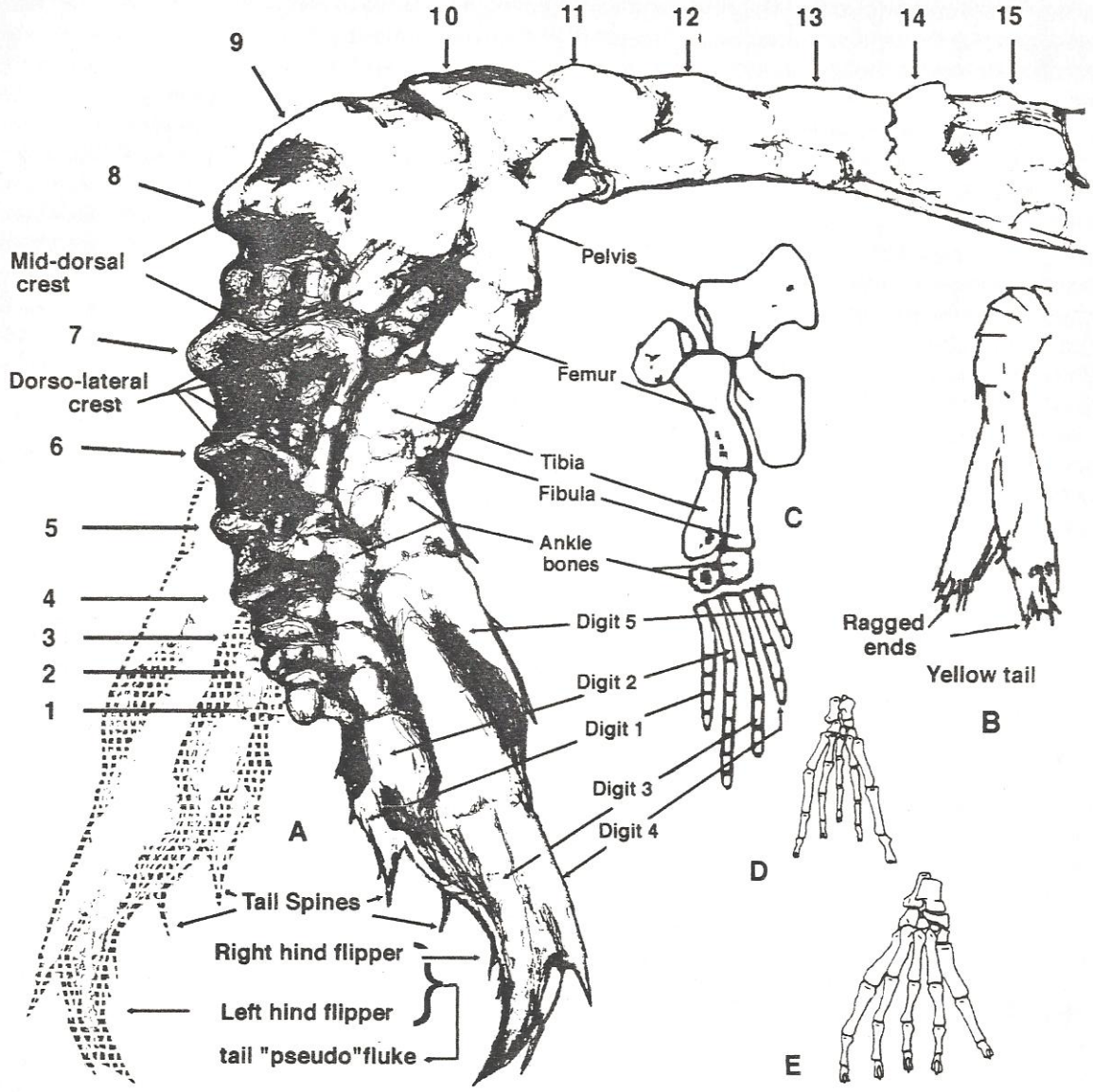

FIG. 13. A. TAIL REGION OF *CADBOROSAURUS*: RECONSTRUCTION FROM G. V. BOORMAN PHOTO (PARATYPE) NADEN HARBOUR, JUVENILE SPECIMEN (Length- 3.2 m) (numbers correspond to probable vertebral segments from apex of tail). B. . TAIL REGION OF BABY *CADBOROSAURUS* (Length- 40 cm) (after Hagelund, 1987). BONES OR RIGHT HIND FLIPPER OF: C. PLESIOSAUR (*Cryptoclidus*); D. Seal (*Monachus*); E. Walrus (*Odobenus*). (C. - after Norman, 1985); D, E. - after Wyss, 1989).

derived (Fig. 13). The print was enlarged from a small negative so that details are not crisply outlined. However, in our view, the photo image reveals structural details as usefully as do the trace images of many rock fossils on which interpretations of new taxa are regularly validly based. Our diagnostic interpretation of the Boorman two-dimensional photo images may prove to be incorrect, but at present it seems reasonable, and consistent with the anecdotal and eye-witness evidence. Thus, the structure of the right hind flipper corresponds proportionately and position-wise with the skeletal structure of the right hand flipper of a Mesozoic plesiosaur, including the uneven lengths of the presumed pedal digits (Fig. 13C). As outlined above (p. 10) the paired rear flippers of the whale stomach specimen correspond generally in relative size, length, position, and posterior spination to those of the presumed baby specimen sketched and described by Hagelund (1987) (Fig. 13B). However, the hind foot of *Cadborosaurus* less closely matches the subequal, clawed digits of the pedal region of pinniped mammals such as true seals and walrus (Figs. 13D, E). In those mammals, thrust is provided by alternating strokes of the hind flippers (Wyss, 1989), not in unison as in the large webbed hind limbs

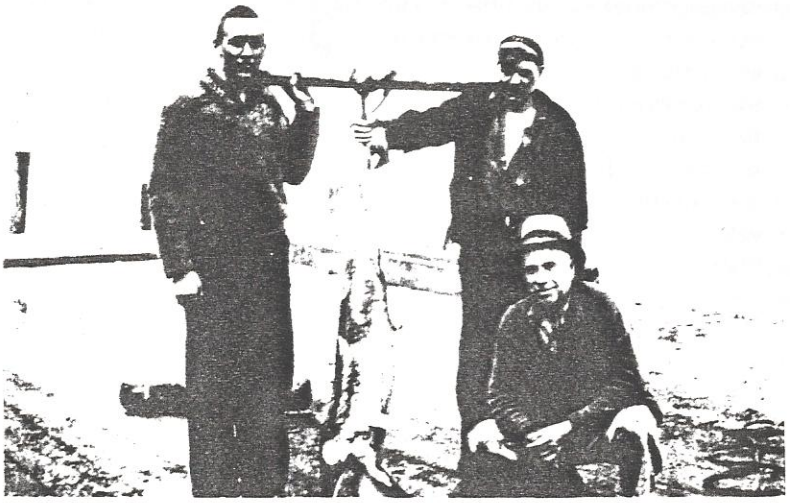

FIG. 14. Fetal Finback (Baleen) Whale at Naden Harbour Wharf, July, 1938.
(Personnel: A. Nixon, Blacksmith Ass't; James Wakelen, Blacksmith; James Wakelen, Sr. Acc't)

of frogs, and presumably here also in the webbed caudal appendage of *Cadborosaurus*.

A few features of *Cadborosaurus* appear mammalian. The reported presence of "whiskers" in the snout region (Fig. 19), unknown in modern reptiles, may represent convergently evolved scales of a sensory function. In birds, bristles (specialized feathers) form the eyelashes of rheas, and nostril coverings of crows, and are well developed around the mouths of nightjars and goat-suckers where they serve as food nets and possibly also as sensors of tactile information (Gill, 1990; Godfrey, 1966).

PROFILES OF LIFE STYLE AND BEHAVIOUR

Life Style.

In the absence of preserved specimens, or of live specimens in an enclosed study environment, the determination of basic features of the life style and physiology of this elusive aquatic species is derived mostly indirectly, and as a working "profile". We present these variously speculative outlines, not as established fact, but as reasonable bases for further investigation. These profiles have been deduced through comparison with morphologically similar but better known animals, or with morphologically dissimilar animals having similar life styles. Lack of a study specimen has prevented analysis of the skeletal, especially cranial, structure, thus precluding categorization at subclass and ordinal levels (p. 8, above). Nonetheless, conclusions drawn in this manner may prove of value in predicting where and when, and under what conditions, animals may be more closely or more favourably studied in the wild. They may also assist others in protecting the species from further encroachment on its natural environment by human activities.

Analysis of the animal's morphology, the presence of a juvenile specimen in the stomach of a sperm whale that hunts large bottom-living animals at depths of 300 - 1000+ m along the continental slope, and the rarity of sightings at the surface, indicate strongly that *Cadborosaurus* is a denizen of deep, cold, offshore waters. It has also been encountered at the surface of deep coastal channels and fiords such as Johnstone Strait, the Strait of Georgia, and Saanich Inlet. The species may also be anadromous since small (presumably juvenile) specimens have also been recorded from coastal fresh water Harrison Lake, about 100 miles above the mouth of the Fraser Delta (Rendall, 1981). The possibility that "Ogopogo", the long recorded and morphologically similar "serpent" of Lake Okanagan (Gaal, 1986; Mayhew, 1991) is a land-locked version of *Cadborosaurus* merits further study.

At near-shore marine locations, *Cadborosaurus* has been observed feeding on several kinds of fishes, including salmon, and sea birds at the surface (several observations), but at depth it is presumed to feed mainly on fishes and squid (LeBlond & Bousfield, 1995). Its maximum speed of swimming is very high (see below). Such would facilitate capture of elusive prey organisms, and escape from predators, especially in its juvenile stages. Its eyes are large, reflective, and presumably adapted for vision in the low light intensities of oceanic depths, and of surface waters by night.

Reproductively, the species apparently bears its young in the relatively warm shallows of the Gulf Islands region during the summer months and may be viviparous (p. 20). Although more detailed aspects of its feeding, swimming, reproductive, and metabolic activities are treated below, nothing is known of its parasites, grooming behaviour, and other biological features.

Aspects of Feeding Biology and Behaviour.

With respect to feeding behaviour, the strongly toothed "fish trap" jaws of adult animals indicate a carnivorous life style. The relatively small size of the head and long slender

neck would presumably restrict the size of its prey to small and medium-sized fishes, squid, and perhaps shrimp. However, the reported breadth of the head and jaws might enable it to take larger prey, in snake-like fashion. The high swimming speed noted below presumably enables the species to capture fast-moving prey animals (e.g. salmon, mackerel, small tuna, and squid), meanwhile avoiding (as adults) presumed potential predators such as killer whales *(Orca)*, sperm whales (*Physeter*), and possibly the great white shark (*Carcharodon*) and giant squid *(Architeuthis)*.

The large reflective eyes of *Cadborosaurus* presumably function in detecting deep-swimming fishes and squid in the "twilight zone" of mid-ocean depths, or in taking prey at the surface nocturnally, by moonlight or starlight. They also function well in broad daylight. In this regard, C. B. Andrews of Pender Island signed an affidavit that, in 1934, he actually watched, from a distance of 10 feet, a 40-foot serpent gulp down a wounded duck. During February, 1944, Mrs. Elizabeth Rhodo and her husband, now of Nanaimo, B. C., observed a large (~30 m) *Cadborosaurus* , with 3-4 body humps, consume about 12 sea birds at the surface of Witty's lagoon, west of Victoria, B. C., all within the space of about 8 minutes (personal communication). Consumption of sedentary bottom organisms and/or carrion seems less likely.

Despite lack of direct evidence, the sea serpent may utilize some form of sonar system in detecting prey, avoiding predators, and/or in long distance communication with other members of its species, as in cetaceans. The curved upper head surface is perhaps suggestive of some duck-billed dinosaurs in which tubular resonating passages contribute to production of auditory vibrations (Norman, 1985). In aquatic reptiles, as in aquatic mammals, a form of sonar system for the detection of prey organisms might reasonably be anticipated.

The food and feeding of the new-born young and early juveniles, living in the inshore shallows of southeastern Vancouver I. and the San Juan Islands, has not been observed. Dietary items presumably include small pelagic fishes and crustaceans. However, very young animals, which swim close to the surface (Hagelund, 1987) may themselves be the prey of bald eagles (Phyllis Harsh, personal communic).

Locomotory Behaviour and Navigation

A major behavioural characteristic of *Cadborosaurus* is its very high swimming speed, rivalling that of marlins and other swift ocean predators (Ommanney, 1963). On numerous occasions, large animals have been clocked at 10-20 m.p.h., occasionally at 25 m.p.h., and on one occasion, when pursued unsuccessfully by a taxiing float plane at the surface, at 30-40 m.p.h. (D. Barends, Cooper Air Services, personal communication). Small motor boats are routinely unable to approach even juvenile (2-3 m.) animals which can also sink quickly out of sight, without "porpoising", or exposing other portions of the trunk and tail.

McGowan (1994) has explained the high speed swimming mechanics of large scombrid fishes, mako sharks, and porpoises. The motion of these animals through sea water is characterized by a high value of a Reynolds number based on their length, and hence a relatively small influence of frictional forces compared to inertial effects. In essence, their bodies are smooth, rigid, typically thunniform, and offer minimum drag with the fluid medium. They also have narrow-waisted, symmetrical tails with rear vortex generators (finlets) that provide maximum forward thrust, whether driving in vertical (fish tail, Fig. 15C) or horizontal (whale fluke, Fig. 15D) planes. The thunniform mechanism contrasts with the lateral undulating movements of eels and sea snakes that require frictional purchase of the entire body for forward thrust. High speed cannot be achieved in such instances because of immense surface drag forces.

High speed swimming in a snake-like animal such as *Cadborosaurus* would therefore seem paradoxical, and the mechanism baffling. However, cognizant of McGowan's work (above), we present an hypothesis, termed "locomotory body transformation", that seems consistent with numerous observations of Caddy's uniquely multi-humped body when travelling at the surface at high speed. Vertical loops have been mentioned in other cryptids swimming at the surface such as "Ogopogo" of Lake Okanagan, the North Atlantic "merhorse", and Storsjoodjuret of Scandianavian deep lakes (see Heuvelmans, 1968).

Swimming propulsion in *Cadborosaursus* is almost certainly generated by the large and powerful fluke-like caudal region. The animal is able to reduce the very great drag effect of its snake-like body at rest (Fig. 15A) by transforming the trunk region into a series of vertical loops or humps in tandem (Fig. 15B). Such body transformation effectively results in a relatively short, rigid, longitudinal I-beam, as suggested by the dotted lines above and below the loops. Friction is further reduced as the humps "draft" directly behind each other (as in highway trailer rigs in tandem), and part of the humps, neck and head are elev-ated into the relatively frictionless air medium. The thin, nar-row front flippers presumably serve as hyrofoils in vertical elevation of the trunk, in rapid submergence, or in directional change,as required. Although the fluke-like tail motions are submerged and seldom visible, they are presumably rapid, as in the large thunniform vertebrates (McGowan, 1994), and provide the thrust required to drive the relatively frictionless humped body at the high speeds observed.

As described in a close sighting by Ken Kilner and Richard Smith at Roberts Bay, near Sidney, B. C. (personal communication), the loops move at exactly the same speed, each at a constant height above the surface, and at a constant distance between each. The musculature ripples in a continuous motion "like a travelling wave moving from head to tail", traversing all loops. No side-to-side (snake-like) undulations have been observed, and little wake is customarily created.

Although the mechanics are unknown in *Cadborosaurus*, a vertical bending of the spinal column of the trunk region must take place in forming two or more vertical loops behind the neck. A locking mechanism, to hold the vertebrae rigidly in place against the counter pressures involved, is almost

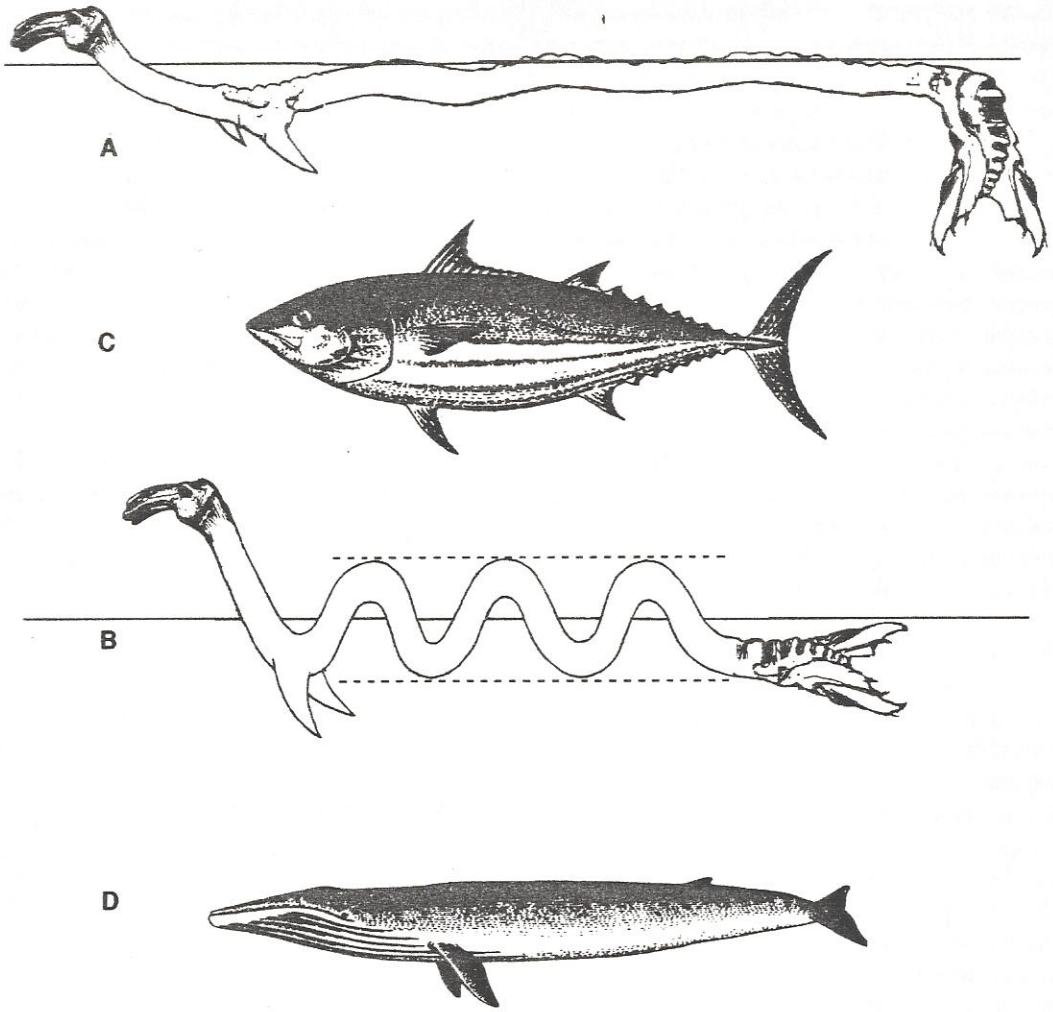

FIG. 15. BODY FORM IN *CADBOROSAURUS* RELATIVE TO LARGE THUNNIFORM FISHES AND AQUATIC MAMMALS A. *Cadborosaurus* (resting at surface) B. *Cadborosaurus* swimming at surface, tuna outline superimposed) C. Tuna D. Rorqual whale (C, D after McGowan, 1994) (not to scale)

certainly present but is also unknown. Such bending has been interpreted, until relatively recently (e.g. Heuvelmans, 1968), as strong evidence of a mammalian ancestry and phylogeny for sea-serpents of the *Cadborosaurus* type. Thus, sea otters and pinnipeds, as well as porpoises and other cetaceans, propel themselves largely by vertical undulations of the tail region, whereas virtually all living representatives of fishes, and elongate amphibians and reptiles, swim by horizontal or lateral undulations of the body and tail.

Buffetaut (1983), however, pointed out that the skeletal structure of Mesozoic marine crocodilians of the infraorder Thalattosuchia made vertical flexure possible (Fig. 16). Thus, in two families of long-snouted Jurassic marine crocodilians (e.g. *Metriorhynchus*, with a reconstructed fluke-like tail), the lateral hypophyses of each vertebra are strongly tilted upwards, nearly as in modern whales, rather than very weakly upwards as shown in the vertebrae of the modern crocodile (Fig. 17). Such vertebral structure allows the animal to hold its body rigid in a vertical plane, and propel itself by rapid up-and-down (rather than side-to-side) movements of the tail flukes. In *Cadborosaurus*, the trunk is capable of looping into two or more vertical coils , and its tail region bends distinctly in a vertical plane (figs. 5, 15). Its vertebrae are, by implication, structurally more similar to those of thalattosuchians and cetaceans than to modern crocodilians. At present, the advantages of maintaining a serpentine body form in the deep-water environment where it occurs, are speculative. Perhaps an elongate body offers less surface area to reflect the sonar "pings" of hunting sperm whales, than does a short and broad body form of the same total bulk. A more basic advantage may involve respiration (p. 20).

Structurally, *Cadborosaurus* appears unlikely to be closely related to crocodiles of any subordinal group, recent or fossil. However, similar modifications of the vertebral

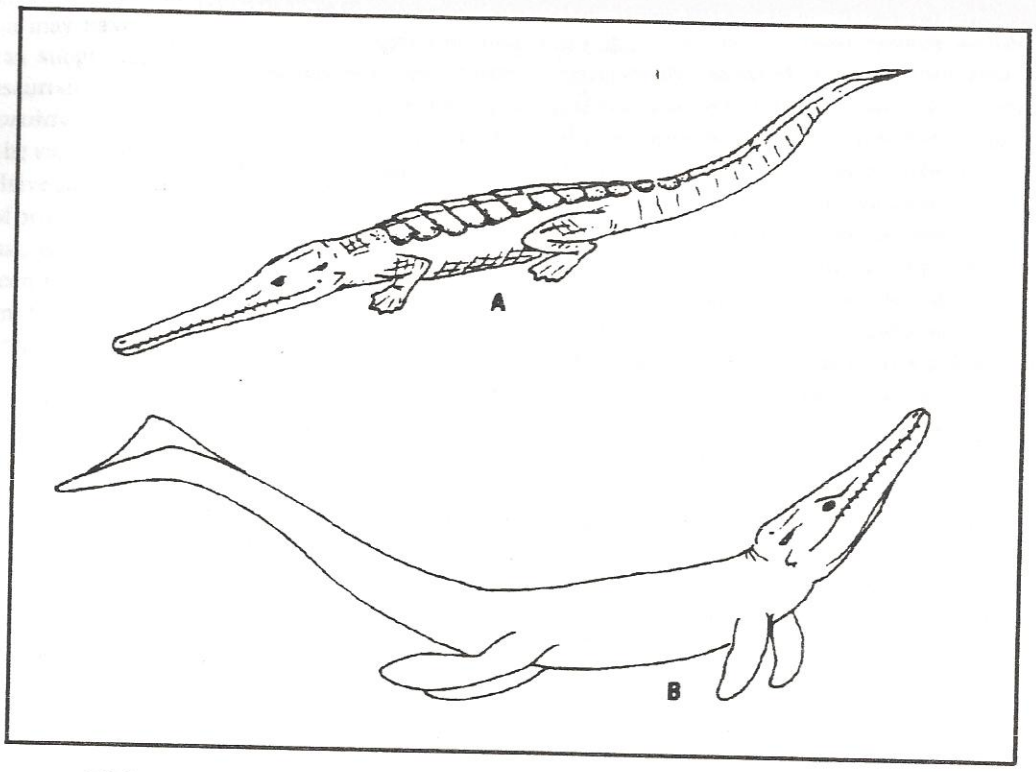

FIG. 16. Reconstruction of Jurassic thalattosuchian reptiles A. *Steneosaurus* B. *Metriorhynchus* (after Buffetaut, 1983)

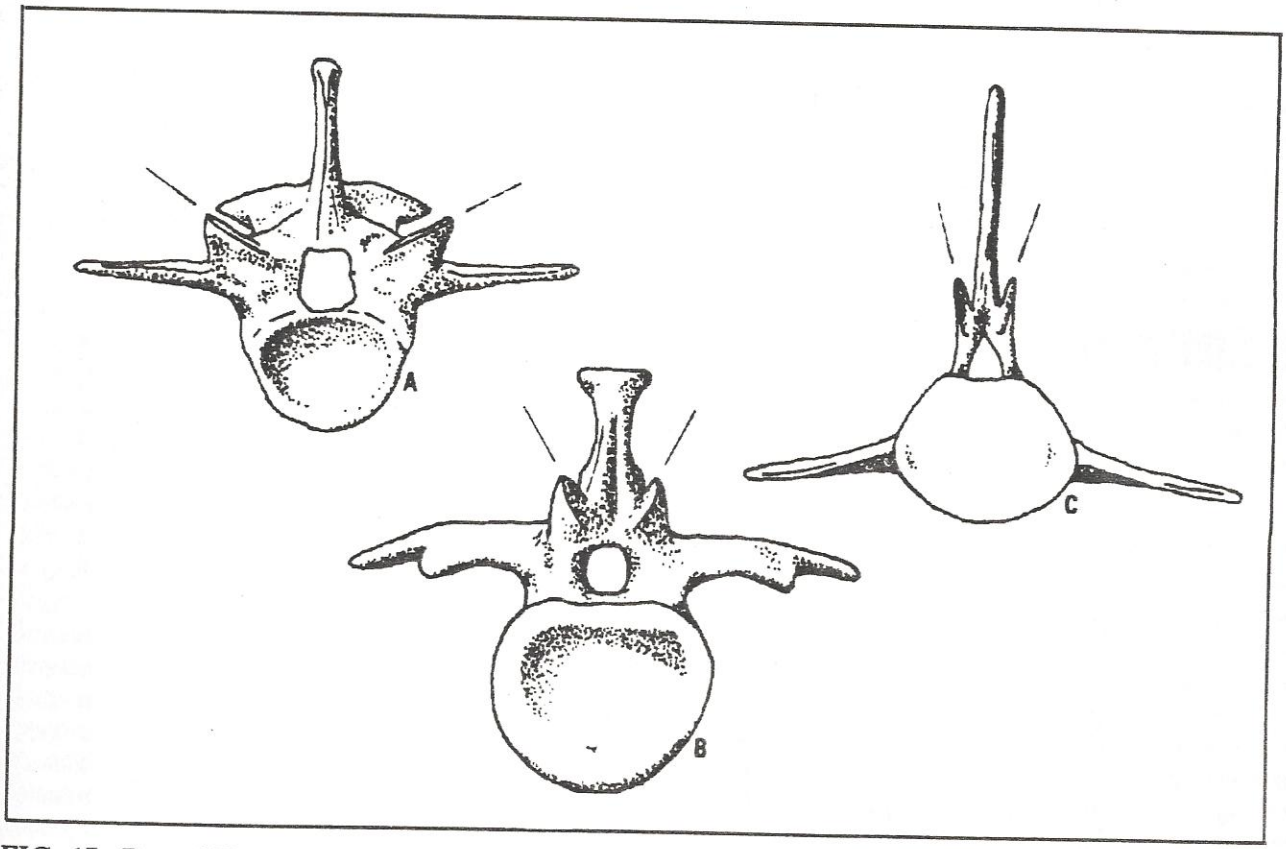

FIG. 17. Dorsal Vertebrae of Reptilia (Crocodilia) and Mammalia (Cetacea) (after Buffetaut, 1983) (A) *Alligator mississippiensis* (B) Jurassic *Steneosaurus* (C) living whale, *Balaena* sp.

column may have evolved, convergently, in other marine reptilian subgroups, perhaps in parallel to, or within, the plesiosaurian subgroup of the Euryapsida. The fully aquatic *Cadborosaurus*, with its uniquely modified tail propulsion, might be viewed as an advanced representative of a vertically propulsive aquatic group whose ancestors were Mesozoic in time of origin. Regrettably, a fossil record is yet lacking. By contrast, early primitive lobe-finned fishes (coelacanths) had been recorded over a 250+ million-year fossil record, from mid-Devonian to the mid-Cretaceous, but was believed extinct since no subsequent fossil or living specimens were known (Ommanney, 1963). However, in December, 1938, a living specimen of a coelacanth was unexpectedly taken at a remote location in the western Indian ocean (Courtnay-Latimer, 1979). The slow-moving species (*Latimeria chalumnae*) has since been taken frequently, even photographed in its demersal habitat, and has come under intense scientific scrutiny. Paradoxically, the Naden harbour specimen of *Cadborosaurus* (Figs. 6, 8) had been taken more than a year previous to the first finding of *Latimeria*, and in a region relatively accessible to marine biologists and research institutions. However, perhaps partly because of the regrettable handling of the original material during its initial identification (above), and partly through lack of a corresponding fossil record, the sea serpent has remained a "cryptozoological curiosity", unstudied by most of the regional scientific community to date.

With respect to navigation, *Cadborosaurus* has been observed, on several occasions, to swivel its head when swimming at the surface (Fig. 5). Such swivel-headed ability would be consistent with visual acuity in air, and with orientation to distant points of reference while the animal is navigating along a coastline.

Cadborosaurus has occasionally been seen near or on shore, in the tidal zone, and is capable of forward and backward slithering movements, aided by its front flippers (P. Harsh, T. Osland, personal communication). In darkness and high humidity, the animal is conceivably able to navigate short distances along shallow waterways, or even across land. Although a form of supratidal terrestrial locomotion has apparently been observed in the "Loch Ness monster" (Mackal, 1976), and in the Storsjoodjuret (Oscarsson, 1991), *Cadborosaurus* has not yet been observed on land above the extreme HW level. The presence of this animal in the tidal zone has coincided with a nauseous odour, resembling rotten meat or fish, that persists long after the animal has departed (Osland, Harsh personal communication; Heuvelmans [1968]). The source of the odour is unknown, but may be an axial glandular secretion of phenylalconoic acids, as in some snakes and especially musk turtles that emit an especially malodorous stench (Ernst et al, 1994). Speculatively, and in accordance with Ehrenfeld & Ehrenfeld (1973), such an odour might have defensive value for birthing females who, with their new-born young, are presumably then briefly vulnerable to land-based predators, including mink, otter, and raccoon, as well as the larger cougar, wolf and bear.

Reproductive Aspects

Little is known about reproductive behaviour in this species. However, Captain Hagelund's fortuitous capture of a very small live specimen near Gabriola Island in August, 1968, may prove significant (Fig. 9). Phyllis Harsh (personal communication) apparently handled a specimen of similar size and appearance, possibly identical with that of Captain Hagelund, at the low water level of a beach near her cottage on Johns I., San Juan Archipelago, during July, 1991. Unfortunately for science, both specimens were released within a short time of capture. In view of the opinions of the finders, and lacking an alternative more plausible explanation, these small animals are here concluded to be the young of *Cadborosaurus willsi*. Because of the relatively limited mobility of these small specimens, their capture data suggest a probable birthing locality and birthing period for the species, namely the Gulf Islands region during summer months.

With respect to reproduction, summer/winter differences in distribution of sightings of *Cadborosaurus* may prove significant. Thus, when 187 sightings (for which the most reliable source data are available) are analyzed (LeBlond & Bousfield, 1995), peak numbers are recorded in the Strait of Georgia and the Canada-U.S. Gulf Islands during the period April - October. By contrast, sightings from the outer Strait of Juan de Fuca and at outer coast localities are most frequent during winter (November through April), and infrequent there during the summer. If sightings were of driftlogs, floating algae, and other surface flotsam, instead of living, moving animals, one might expect relatively little regional or seasonal differential. On the other hand, where highly mobile animals are involved, such difference might suggest a seasonal migration from one location to another. Plausibly, reproductive adults of *Cadborosaurus* might move from their presumed principal feeding grounds along the outer continental slope, into the relatively warm waters of the Strait of Georgia for reproductive purposes. In the fall and winter the animals presumably return to their primary offshore feeding grounds.

A dearth of records of the sea-serpent from arctic and subarctic waters and from cold-water, eastern N. American embayments (e.g. St. Lawrence estuary) is consistent with its absence from Pacific coastal waters that fall below ~4°C. However, little can yet be surmised concerning post-natal dispersal of first-year animals.

As in sea snakes, *Cadborosaurus* may bear its young alive (viviparity). The fore and hind flippers of *Cadborosaurus* would appear unsuitable for digging a nest on the shore in which to lay eggs. In any event, immersion in sea water and/or in cold tidal sands are regional factors not conducive to incubation of eggs. Live-bearing is common in modern species of lizards and snakes, especially those that are aquatic or live in cold climates. The phenomenon is also known, from the fossil record, in at least one Mesozoic euryapsid reptilian group (e.g. ichthyosaurs: see Norman, 1985; Carroll, 1988). Most aquatic reptiles, and other secondarily aquatic vertebrates, go ashore for reproductive

purposes, mainly at night, and/or on a regularly annual or seasonal basis (Carr, 1963). Of recent (modern) higher vertebrates, only the whales (cetaceans) and allies and some sea snakes (e.g. *Pelamis* spp.) do not go ashore, but bear live young in the water (Dunson, 1975). In cetaceans the young are born in water that is relatively warmer and shallower than that of the adult feeding grounds (Carrington, 1963).

Reptilian young are precocial (fully developed and independently active at birth) rather than altricial (incompletely developed and helpless at birth, as in many birds and mammals). Reptilian precocial young seldom receive postnatal care from the mother, except in crocodiles, a few snakes, and perhaps in some advanced dinosaurs, in contrast to the situation in mammals and birds generally. Reptilian precocial young (e.g. baby turtles, crocodiles) are typically tiny in relation to the size of the mother, whereas precocial young of mammals (e.g. colts, fawns, whale calves) and most birds, are relatively large. In perspective, the human species fits somewhere in between these categories but is essentially altricial. In all the characteristics above, evidence to date for *Cadborosaurus* in the B. C. coastal region suggests that its life cycle is a somewhat advanced reptilian type. Thus, our sightings data base indicates that large reproductively active adults swim into relatively warm shallow inshore waters during spring and summer and, on or near the beaches, presumably at low tide, and at night, females bear live precocial young. The young are of relatively small size that fend for themselves, and apparently remain in relatively shallow water, at least for a brief period. Such a scenario is not inconsistent with that of other marine reptiles and is therefore proposed as a basis for more extensive field studies on actual reproductive processes in this species.

PHYSIOLOGICAL ASPECTS

Physiologically, *Cadborosaurus willsi* would appear to be poikilothermal and reptilian rather than homeothermal and mammalian. Thus, an uninsulated, slender, serpentine body form, with high ratio of surface area to body volume, would seem incompatible with conservation of endothermic body heat in the cold northern waters (4-12°C.) in which *Cadborosaurus* normally dwells. Internally regulated heat balance, under those conditions, would necessitate near-constant feeding and enormous conversion of food energy to compensate for continuous rapid loss of body heat. On the other hand, a poikilotherm, even a large one, living under such conditions, would presumably require little energy for heat production, and thus require relatively little uptake of food over a given period of time. Metabolic rates could then remain relatively low, with the low frequency of O_2-CO_2 exchange at the sea surface that typifies the respiratory behaviour of *Cadborosaurus* (below). Similar (or related) serpentine animals of deep cold northern lakes (above) could thereby exist in the depths during long winter periods, with very low food intake, fully consistent with estimated small stocks of prey organisms. High energy production might then be conserved mainly for rapid pursuit of prey organisms, or eluding potential predators (above). It might also possibly be conserved for cranial endothermy, a remarkable physiological efficiency of the central nervous known in some warm-water scombrid fishes. Such mechanisms enable warm-water fishes to operate in more north-erly and/or deeper (and therefore colder) waters than species not so equipped (Block, et al, 1993). However, scarcity of sightings of *Cadborosaurus* in surface waters of the Gulf Islands region during the summer months of July and August relative to those of April and October (LeBlond & Bousfield, 1995) may indicate an avoidance of the relatively high surface temperatures at those times. Thus, animals normally acclimatized to subthermoclinal temperatures of 4-12°C. conceivably might suffer thermal stress in surface waters of 15-20° C. (or higher). Upward excursions into the surface waters in summer would presumably involve higher metabolic rates, greater expenditure of energy, and more frequent air respiration (see below).

Comments on Respiratory Physiology

Although *Cadborosaurus* is seen only occasionally at the surface, the reptilian sea serpent is presumed to be capable of air-breathing. Several observers have described nostrils at the snout end of the head, and some have observed "steam" or "jet" emissions from them, and a "whooshing" sound accompanying such presumed respiratory activities (data base). Because the trunk region is slender (except in very large individuals), the lungs are probably elongate, as in snakes and some lizards (Carr, 1963). In sea snakes, the right lung is developed and extends to the base of the tail (Dunson, 1975). As in many other pelagic marine and fresh-water organisms that respond actively to changing light intensities, *Cadborosaurus* may routinely undertake diurnal migrations, vertically from the depths to the surface in the evening, and from the surface to the depths at daybreak. During darkness, its air respiration at the surface may be more frequent. Diurnal respiratory differences are thus possible, but would be very difficult to detect, even from shipboard, and little evidence on this point is available.

However, the possibility of a secondary aquatic respiratory mechanism has also been proposed in the "merhorse", a superficially similar sea-serpent of the North Atlantic (Heuvelmans, 1968: 553). Such a proposal gains credence from the infrequent appearance of the animal at the surface, its frequent failure to raise its head out of the water when at the surface (p. 5), and its apparent prolonged duration of submergence, especially during the daytime. Both features contrast with those of the fully aquatic but air-breathing and homeothermal cetaceans (whales and relatives) of similar open ocean water habitats. Cetaceans seldom remain submerged for more than one hour's duration, and breathe "automatically" when emerging or breaching at the surface. Furthermore, presumed fresh-water relatives of Caddy (e.g. "Memphry", "Champ", and some populations of the Scandinavian "Storsjoodjuret") occur in deep lakes (data base, LeBlond & Bousfield, 1995) that are apparently frozen over for several weeks or months during the winter period. Under such conditions, and in the presumed absence of

breathing holes through the ice, air respiration is assumed to be impossible or unlikely. Metabolically active aquatic animals, even at low bottom temperatures (4-5°C.) would then require some form of aquatic respiration.

Within Class Reptilia, respiration in advanced (diapsid) aquatic subgroups such as crocodilians, sea snakes, and marine iguanas is essentially pulmonary. In sea snakes, the right lung is elongate and the trachea (windpipe) has been modified to provide an area for exchange of gases (Dunson, 1975). Sea snakes have an increased tolerance for anoxia which allows them to pay off an "oxygen debt" after they return to the surface, with submergence times of 2-8 hours. However, a considerable proportion of the total oxygen exchange occurs through the skin of some aquatic snakes (Dunson, loc. cit.). Carbon dioxide diffuses through animal tissue about 36 times faster than does oxygen. The skin of aquatic snakes is presumably more effective in losing CO_2 than in taking up O_2. Skin respiration is relatively higher in smaller snakes because of larger surface area to volume and is higher in metabolically active than in resting animals.

Secondary aquatic respiratory mechanisms are also known from primitive anaspid reptiles, including certain freshwater turtles (Chelonida). In the northern hemisphere, some species overwinter in bottom muds for durations of 4-6 months. At ambient temperatures of 4-5° C., metabolic rates in such animals are very low, requiring no food uptake, but are marked by a very limited dissolved O_2 -CO_2 gaseous exchange across cloacal and/or buccal membranes (Carr, 1963; Ernst et al, 1994). Metabolic rates are considerably higher in large coastal fresh water and estuarine turtles (*Carrettochelys insculpta*) of northwestern Australia where water temperatures are 25-30°C. Adult animals are large (40+ kg. in body weight), feed on plant and organic detritus, and rest on bottom substrata for prolonged periods. Recent field studies have demonstrated a buccopharyngeal mucosa deep within the mouth and throat of these animals. The respiratory papillae are continuously flushed with water pumped in through the mouth and expelled through the nostrils (Legler & Winokur, 1983). Similar pharyngeal breathing is known in the long-necked African softshell turtle, *Trionyx triunguis* (Ernst & Barbour, 1989). Moreover, respiration in large, aquatic, long-necked Mesozoic reptiles of intermediate (euryapsid) ancestry (e.g., deep-diving plesiosaurs and elasmosaurs), might not have been entirely pulmonary.

Thus, in the modern reptilian *Cadborosaurus*, that inhabits deep offshore waters and is seldom seen at the surface, mechanisms of aquatic respiration would appear probable. However, retention of an elongate body form, in which the ratio of surface area/body volume is high, even at larger and later life stages, would suggest that cutaneous respiration may account, at least in part, for the species' ability to remain submerged for prolonged periods. In some very large animals, mane-like growths along the nape of the neck may also be respiratory in function (see Heuvelmans, 1968, p. 553). These long, hair-like filaments have been described as reddish in colour, suggesting a haemoglobin content.

Possible Phyletic Relationships of Cadborosaurus

The previous description of the morphology and life style of *Cadborosaurus willsi* conforms best with vertebrate animals having reptilian affinities. A profile of *Cadborosaurus willsi*, based on analysis of nearly 200 published records and sketches, 3 different photos of an actual specimen, and other historical evidence, suggests strongly that the morphological relationships and behaviour of the species are more closely reptilian rather than fish, amphibian, avian, or mammalian. Thus, a large serpentine body form, with long neck and small head, and with two pairs of limbs, is known to science only among a few subgroups of reptiles, all paleontological, including the diapsid terrestrial dinosaurs, and the euryapsid aquatic sauropterygians (nothosaurs, plesiosaurs and elasmosaurs (see Romer, 1956; Norman, 1985; Carroll, 1988).

Several large aquatic Mesozoic sauropterygians, notably *Pachypleurosaurus* among the nothosaurs (Fig. 18), and *Pistosaurus* among the advanced (plesiosaur-like) nothosaurs, do show various degrees of overall resemblance to the external body form of *Cadborosaurus* . Similarities include an elongate body, long neck (~ 10 vertebrae), long powerful propulsive tail, limbs variously specialized for aquatic locomotion, and small head with "fish-trap" teeth and anteriorly directed large eyes (sockets) (Carroll, 1988). A superficial resemblance between the posterior limbs of *Cadborosaurus*, and those of the plesiosaur *Cryptoclidus* has been noted previously (Fig. 13). However, the trunk region of these fossil euryapsids is relatively short and broad, the true tail is distinctly longer (20-30 vertebral segments), and is not fused with the hind flippers into a fluke-like propulsive element, but tapers independently to an acute tip. In swimming action, the body may have undergone lateral undulations, and the flippers probably acted independently and alternately. Moreover, the vertebral column would seem incapable of the tight dorso-ventral bending required to form the vertical humps or loops of the *Cadborosaurus* trunk region.

Early Mesozoic sauropterygians may have been oviparous, since the hind flippers were developed and perhaps capable of nest-building on warm sandy beaches. However, the short-necked, short-tailed euryapsid ichthyosaurs included at least one fully aquatic viviparous species. The female had been fossilized in a position in which the precocial young was being born alive, tail first (Carroll, 1988), apparently in the water column, without coming ashore, similarly in modern fully aquatic sea snakes and cetaceans.

Some authors (e.g. Mackal, 1980) have looked for the ancestry of sea serpents among the early aquatic mammals. *Zeuglodon*, a large aquatic mammal of the Eocene (Cenozoic Era) is believed ancestral to modern whales. Reconstructions of this animal (body length ~20 m.) grossly resemble *Cadborosaurus* in having a trunk region like that of an elongate sea lion, paired anterior paddle-like limbs, and a fluke-like tail. However, the body and neck were relatively short and thick, the latter with only ~6 vertebrae, the hind limbs were vestigial or totally lacking, and the animal was almost certainly homeothermal rather than poikilothermal. .

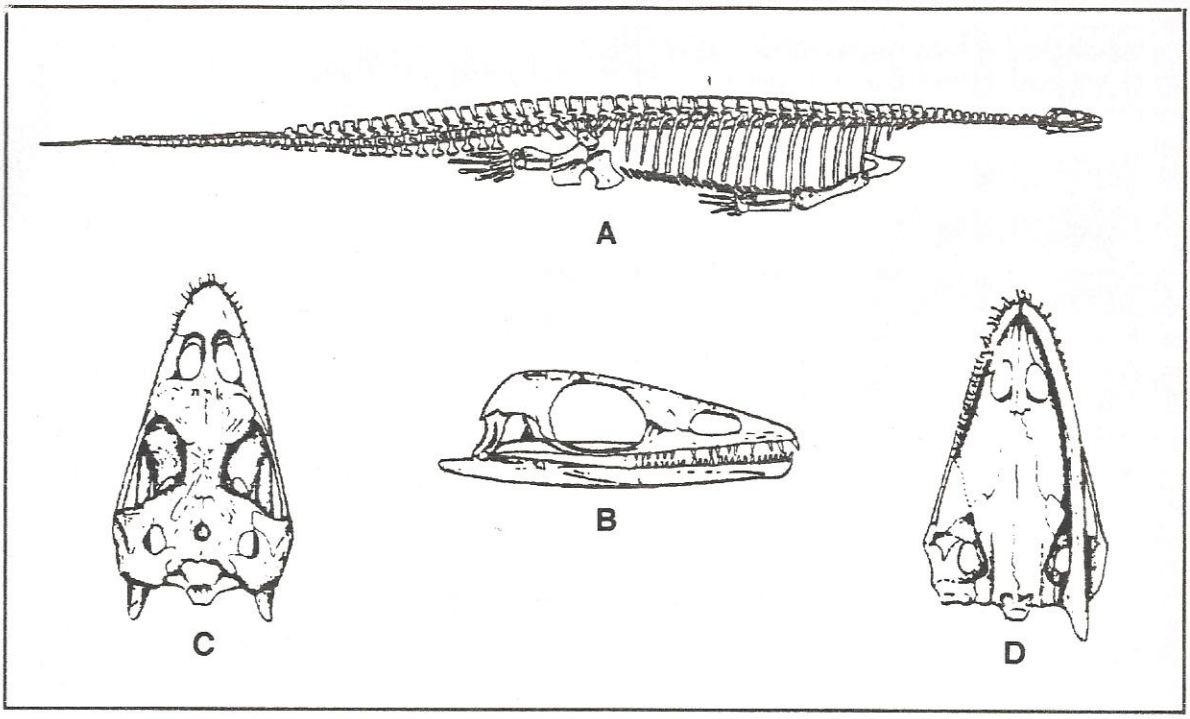

FIG. 18. Skeleton of Middle Triassic Nothosaur *(Pachypleurosaurus* sp.) A - Skeleton, lateral view B - Skull, lateral view C - Skull, dorsal view D - Skull, ventral view (after Carroll, 1988).

However, a 40-million year old baleen whale precursor, *Basilosaurus isis* , worked on by P. Gingrich and H. Smith of University of Michigan, and E. Simons of Duke University, was a more plausible early relative (Kingsmill, 1990). The body was the size of an adult *Cadborosaurus* (16 m) with an extremely long slender trunk and medium tail, a relatively small head with toothed jaws, and short paired pectoral fins. However, the species had a very short neck (~6 short vertebrae), the hind limbs were vestigial, its physiology probably homeothermal, and its similarity to *Cadborosaurus* thus more likely homoplasious than phyletic.

Although its swimming mechanism is here hypothesized but not yet "tank tested", the locomotion of *Cadborosaurus,* and apparent ability to flex its vertebral column strongly into two or more vertical loops, are features unique among vertebrate animals, living or fossil, aquatic or terrestrial. These features may therefore prove significant at major taxonomic levels.

The *Cadborosaurus* morphotype is closely similar to that of other large modern serpentine cryptids of both marine and fresh waters. These others are known individually as "Nessie", the Loch Ness phenomenon (McGowan, 1976); "Storsjoodjuret" of deep Scandinavian lakes (Oscarsson, 1991; "Champ" of Lake Champlain (Zarzynski, 1984), "Ogopogo" of Lake Okanagan (Gaal, 1986; Mayhew, 1991), "Chessie" of Chesapeake Bay, and the merhorse (*Halshippus olai-magni* Heuvelmans, 1968) of North Atlantic marine waters. Gross similarity of body form and life style in all these cryptozoological entities are merely noted here, but possible relationships are discussed elsewhere by the authors (LeBlond and Bousfield, 1995). The probability that these organisms are real, and possibly one and the same widely eurytopic, anadromous, and/or freshwater holartic species merits further consideration.

With respect to classification of *Cadborosaurus* within the Vertebrata, the present description of its external morphology and more conspicuous behavioural traits conforms most closely with that of Class Reptilia. We might also look, for further evidence, to simple numerical analysis of some character states that are considered significant at ordinal and class levels. However, the number of major character states reliably available was found to be insufficient for such formal taxonomic treatment.

For the present, we may note that, in overall body form, *Cadborosaurus* more closely matches Mesozoic euryapsid plesiosaurs than any other vertebrate animal group, living or fossil. However, until the skeletal (especially cranial) structure of the species can be studied, intermediate levels of classification of this new taxon remain imprecise.

Recommendations and Suggested Further Studies

Cadborosaurus continues to be sighted in the southern Vancouver Island region to the present date (8 sightings in 1994). However, about 70 percent of published records from the 20th century occur during the 1940's to 1960's, in all months of the year (LeBlond & Bousfield, 1995). Records from the outer coast tend to be more frequent in winter months, whereas those in the Strait of Georgia predominate in spring through early fall. A regional breeding population is apparently present, but its size is problematical. However,

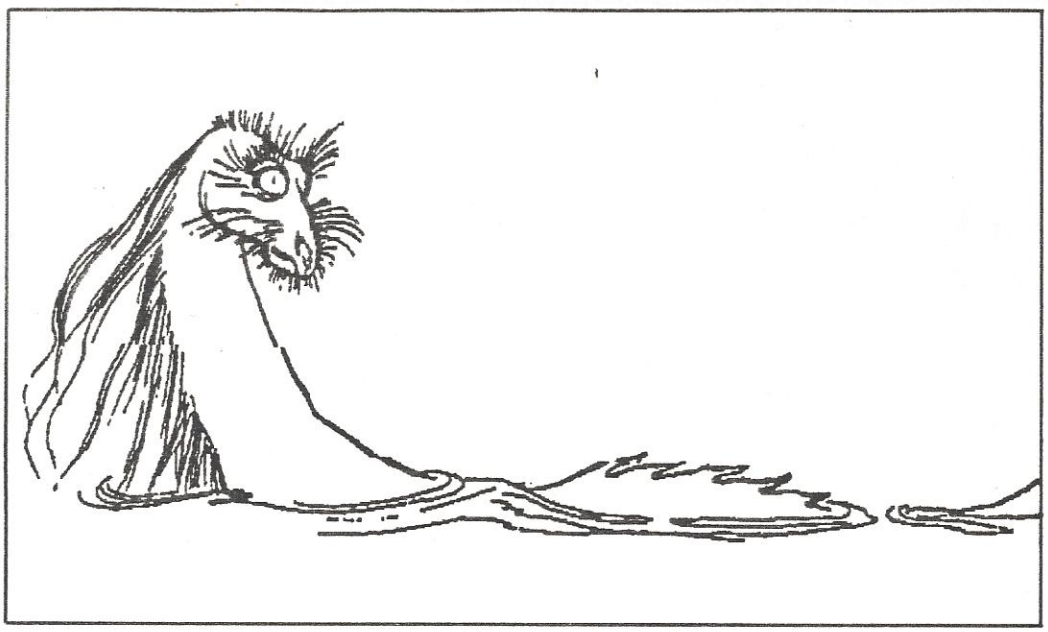

FIG. 19. Merhorse *(Halshippus olai-magnai)*, North Atlantic region (after Heuvelmans, 1968)

barring sudden catastrophe to this population, the reality of the species justifies prediction of further sightings in the waters around the Saanich peninsula during each of the next several years. The relative scarcity of records and news media reports during the past 20 years may indicate that the species is less common today than during the 1930's, 40's, and 50's. However, the sightings data provided by LeBlond and Bousfield (above) do not critically establish such a trend. The authors would recommend that the aquatic reptilian species *Cadborosarusu willsi* be further investigated for possible placement on the major authoritative Endangered Species list established by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Detailed study of the systematics and biology of this remakable species necessitates study specimens, either preserved, or live-held in aquaria. Video camera sequences would facilitate study of swimming and feeding activities of the animal at the surface, under natural conditions. Aerial surveillance, from float planes and helicopters in regions of presumed reproduction, at suitable times, and under suitable conditions of surface light intensity, could determine actual breeding and birthing localities more precisely.

The possible capture of very young (new-born) specimens at presumed sites of reproduction, from surface vessels or from shore, under suitable physical conditions. Small specimens might then be transferred to regional marine aquaria for detailed study of swimming, feeding, and respiratory behaviour.

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